ARLINGTON COUNTY

PENTAGON CITY METRO STATION SECOND ELEVATOR PROJECT

ARLINGTON COUNTY CONTRACT INVITATION TO BID NO. 20-235-9
WMATA PROJECT #: 251666
STV PROJECT #: 4018669

TECHNICAL SPECIFICATIONS

INVITATION TO BID

November 20, 2020

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STANDARD SPECIFICATIONS - RELEASE 9, REVISION 3B

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DIVISION 2 - SITE CONSTRUCTION

SECTION 02205

REMOVAL AND RESTORATION OF EXISTING FACILITIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies removing, restoring and reinstalling miscellaneous facilities on public and private property which are removed during construction.

B. Related Work Specified Elsewhere:
1. Demolition: Section 02220.
2. Grading, excavating and backfilling: Section 02320.
3. Base for pavements: Section 02725.
4. Bituminous pavement: Section 02740.
5. Concrete pavement: Section 02750.
6. Curbs, gutters and walks: Section 02772.
7. Fencing: Section 02820.
8. Topsoil, seeding and sodding: Section 02920.
9. Landscaping: Section 02930.
10. Concrete formwork: Section 03100.
11. Concrete reinforcement: Section 03200.
12. Cast-in-place structural concrete: Section 03300.

C. Definitions:
1. Miscellaneous facilities include, but are not limited to, the following: Store fronts, alarm and sprinkler systems, bay windows, cornices, signs, fire escapes, canopies, awnings, security grilles, heating, cooling and electrical facilities, vaults, entrance walkways, steps, sidewalks, curbs, walls, railings, fences, planter boxes, shrubs, lawns and trees.
2. Definitions pertaining to trees, shrubs and other plants: ANSI Z60.1.
3. .Salvage: To remove and store material and equipment for reuse in this or other Authority contracts.

D. Salvage:
1. Clean salvaged items of foreign material and store in accordance with the General Requirements at accessible points within right-of-way unless otherwise shown, approved or directed.
2. Repair or replace salvaged items which are damaged or destroyed.
3. Unless otherwise specified items removed but not to be salvaged will become the property of the Contractor.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Working Drawings:
   a. Complete details of proposed reconstruction of store fronts and shop windows.
   b. Complete details of temporary signs including method of reinstalling existing permanent signs. Submit prior to removing signs.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ANSI: Z60.1.
   3. ASTM: C4.
   4. ICNCP (International Commission for the Nomenclature of Cultivated Plants): International Code of Nomenclature for Cultivated Plants.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Materials for Restoration: New materials, unless otherwise approved, conforming to existing undisturbed materials in quality, color and finish.

B. Topsoil: Section 02920.

C. Seeding and Sodding: Section 02920.

D. Trees, Shrubs and Other Plants: Same species as that removed, unless otherwise specified, and identified in accordance with the International Code of Nomenclature for Cultivated Plants.

E. Clay Drain Tile: ASTM C4.

PART 3 - EXECUTION

3.01 REMOVALS:

A. Remove work to extent shown minimizing damage to work which is to remain in place.

3.02 STORE FRONTS, BAY WINDOWS AND CORNICES:

A. Store Fronts:
   1. Rebuild store fronts at or behind building line to match existing fronts insofar as practicable.
   2. Complete restoration in accordance with approved working drawings.

B. Bay Windows:
   1.Rebuild bay windows at or behind building line as window walls.

C. Cornices:
   1. Do not replace cornices which have been removed.
   2. Parge areas disturbed by removal with cement plaster.

3.03 ALARM AND SPRINKLER SYSTEMS AND FIRE ESCAPES:

A. Alarm Systems:
   1. Maintain existing alarm systems in operating condition. On completion of construction, reinstall components to provide same degree of protection as original system.

B. Sprinkler Systems:
   1. Maintain existing sprinkler systems fully operative in areas temporarily occupied for construction purposes.
   2. Protect system from freezing where exposed to open-air conditions.
   3. Restore sprinkler system to provide same degree of protection as original system.

C. Fire Escapes:
   1. Relocate fire escapes temporarily and maintain safe egress.
   2. Replace fire escapes in original location as soon as practicable.

3.04 CANOPIES, AWNINGS AND GRILLES:

A. Canopies and Awnings:
   1. Store canopies and awnings during construction.
   2. Reinstall as soon as construction permits.

B. Grilles:
   1. Remove and reinstall security grilles concurrently with building modifications.

3.05 VAULTS:

A. Perform work on vaults as specified in Section 02320.

3.06 HEATING, COOLING AND ELECTRICAL FACILITIES:

A. Heating and Cooling Facilities:
   1. Remove and rebuild heating and air-conditioning facilities as necessary to provide service.

B. Electrical Facilities:
   1. Remove and reconstruct electrical facilities to extent necessary to provide electrical service inside building line.

3.07 SIGNS, FLAGPOLES, RAILINGS AND FENCES:

A. Salvage signs, flagpoles, railings and fences where shown.

B. Provide temporary sign for each permanent sign removed in accordance with approved working drawings. Remove on completion of construction.

C. Reinstall items in their original locations or in other locations shown. Reinstall or replace chain-link fences in accordance with Section 02820.

D. Repair existing surfaces, damaged during the work, by cleaning and restoration to match existing.

3.08 STEPS, WALLS AND COPINGS:

A. Salvage steps and copings of wall components where shown and rebuild them to match existing.

B. Where new reinforcing steel and concrete construction is necessary, provide such items in accordance with Sections 03100, 03200 and 03300 so as to maintain continuity of quality and appearance between existing and new construction.

3.09 SIDEWALKS AND CURBS:

A. Salvage components of sidewalks and curbs where shown. Dispose of six-inch granite curb. It will not be reused.

B. Restore sidewalks and curbs to line and grades which existed originally or new lines and grades shown.

C. Restore asphalt and concrete sidewalks and curbs using new asphalt and concrete of equal quality to existing and to match lines, grades, thickness and construction existing prior to removal. Perform work in accordance with Sections 02725, 02740, 02750 and 02772.

3.10 PARKING AREAS AND DRIVEWAY PAVEMENTS:

A. Restore parking area and driveway pavements to lines, grades, thickness and construction existing prior to removal. Perform work in accordance with Section 02725, 02740 and 02750.

3.11 LANDSCAPING:

A. Tree Preservation:
   1. Repair injuries, abrasions or other damage to planting by cleanly removing broken members, loose or torn bark and shape edges in order to permit drainage of rain water from wounds. Perform pruning in accordance with Section 02930.
      a. Where depth of soil over root system of existing plantings is to be modified by final grading, provide the following:
         1) Where increase of one foot or more in elevation is shown, spread continuous layer of rock aggregate, graded 1/4 inch to two inches, six inches deep from trunk to drip line of branches prior to installation of fill.
         2) Provide proper aeration by installing, within perimeter of spread, system of four-inch clay drain tile, vertically from soil surface into aggregate fill.
         3) Construct stone wells around trunks as shown, detailed or as approved. Extend stone work from rock fill layer to final grade, allowing sufficient space for trunk growth.
         4) Protect trees, shrubs, groundcovers and features such as landforms, walls, wells, coping and similar items that are to remain. Exercise special precautions and provide treatment for retention and protection of such landscape items in preference to removal.

B. Tree Removal and Replacement:
   1. Where existing trees are to be removed and replaced by others at present locations, use replacement trees of comparable species and size up to four inches maximum caliper, except that the jurisdictional authorities have the right to specify alternate tree species or varieties of comparable size and cost, if such are readily available. Do not replant or relocate trees over 12 inches in caliper, except in cases of historical significance, rarity of type, excellence of form or other special considerations.
   2. Replace trees of minimum three-inch caliper, removed by construction, on the basis of diameter inch for diameter inch, up to four-inch maximum caliper, and on total diameter inches removed, so that planting can be complete and uniform throughout.
   3. Use replacement trees of prime specimen quality, field selected and seal-tagged. Measure, grade, install and maintain plants in accordance with ANSI Z60.1, except for National Park Service lands where trees are to be measured for diameter by taking the average of two trunk caliper measurements at right angles, six inches

above the root crown.

4. Replace shrubs removed with same species and varieties and of same size in height or width or substitute at locations designated by the Engineer a number of plants of same species and variety whose total measurements equal measurement of plant or plants to be replaced

C. Plant maintenance and replacements:

1. For 18 months after completion of plant installation, maintain planting and incidental work by replacing plants, watering, weeding, cultivating, fertilizing, remulching, pruning, controlling insects and diseases, reguying, rewrapping and by performing other maintenance operations for promotion of root growth and plant life so that work is in satisfactory condition at completion of Contract and throughout maintenance period.
2. Water and weed root system of plants at regular intervals and keep surrounding soil in condition for promotion of root growth and plant life.
3. Provide planting and planting materials that will be in a condition acceptable to the Engineer at end of maintenance period.
4. During next planting season, replace trees, ground cover, vines and shrubs which are discovered during and at end of maintenance period to be dead or in unhealthy, unsightly or badly impaired condition. Replace with healthy plants of same kinds and sizes as originally specified.
5. The Contractor will not be held responsible or liable for damages to plants and planting materials by animals, malicious or careless damage by human agencies over which he has no control, or by fire and storm damage following completion and acceptance of original planting.

D. Topsoil:

1. Provide and place topsoil in tree spaces and areas to be seeded in accordance with Section 02920.

E. Grassed Areas:

1. Unless otherwise shown, provide seed in accordance with Section 02920. If sodding is required, provide in accordance with Section 02920.

F. Replace landscaping, trees and grassed areas, inside and outside limits of work, if removed or damaged.

3.12 JOINTS BETWEEN EXISTING AND RESTORED WORK:

A. Make joints between existing and restored work as inconspicuous as practicable.

B. Use saw to cut straight line at joint between existing and new concrete surfaces.

C. Make joints between existing and restored work at least equal structurally to original undisturbed items.

END OF SECTION

SECTION 02220

DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies demolition work.

1. Related Work Specified Elsewhere:
2. Clearing, grubbing, removal and protection of trees and shrubs: Section 02230.
3. Removal of concrete and masonry walls and foundations 12 inches below existing grade: Section 02320.
4. Removal and restoration of miscellaneous facilities: Section 02205.

B. Definitions:
1. Demolition: Complete removal and disposal of existing facilities from areas to be cleared and grubbed and from other areas shown.
2. Existing facilities include, but are not restricted to, buildings, sheds, streetcar tracks, pavements, sidewalks, curbs and gutters, signs, posts, fences, drainage, sewage and other utility facilities located in the area to be cleared and grubbed.
3. Salvage: Section 02205.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Certification:
   a. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by demolition work for discontinuance of services along with certificates of severance.
2. Documentation:
   a. Demolition permit from the jurisdictional agency or owner.
   b. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.

1.04 JOB CONDITIONS:

A. Buildings:
1. Demolish buildings in place.

B. Street and Road Closures:
1. Make arrangements with appropriate jurisdictional agency for temporary closing of public streets or highways to traffic as necessary.
2. Arrange with the appropriate agency for the rerouting of traffic and comply with its regulations.
3. Furnish and maintain temporary signs, barricades, flashing lights and flag persons necessitated by the work and remove same upon completion of work.

C. Maintenance of Traffic:
   1. Construct, maintain and remove on completion of work, temporary canopies and other structures for protection of the public in accordance with applicable codes to ensure continuous safety of traffic.
   2. Bridge cuts in traffic areas with steel plates or by other approved means.
   3. Keep traffic areas free from debris and spillage of materials.
   4. When demolition work interferes with bus loading facilities, provide and maintain surfaced areas at alternative locations or arrange rerouting with appropriate authorities for duration of work.

D. Protection and Restoration:
   1. Prevent damage to pipes, conduits, wires, cables and structures above and below ground which are not designated for removal. Repair or replace damaged items.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 PRESERVATION OF REFERENCES:

A. Prior to removal, record location and designation of survey markers and monuments located within demolition area. Store markers and monuments during period of work. Restore survey markers and monuments upon completion of work.

3.02 BUILDING DEMOLITION:

A. Undertake rodent control and extermination program in demolition areas.

B. Take possession of building materials, fixtures and equipment in, attached to or belonging to, buildings and structures.

C. Proceed with demolition of building or structure and appurtenances.

D. Party Walls:
   1. Where building wall being demolished is a party wall with another building not to be demolished, prevent damage to other building and avoid interference with its occupants.
   2. Restore and waterproof exposed party walls in accordance with applicable building code for exterior walls of particular type of construction involved.
   3. Should party wall become unsafe or dangerous because of demolition, effect remedial measures for anchoring, bracing or buttressing. If such work does not correct unsafe or dangerous conditions, remove and replace wall and perform necessary work to properly enclose structure that is to remain standing, at no cost to the owner of such property.

E. Cellars and Foundation Walls:
   1. Break concrete and masonry cellar floors into pieces not exceeding four cubic feet in volume or, where approved, punch holes of not less than one-square-foot area through full thickness of floor approximately at 10-foot centers.
   2. Remove wooden cellar floors.
   3. Remove foundation and cellar walls 12 inches minimum below final grade.

4. After breaking or removing cellar floors, fill cellar spaces with durable free-draining fill material, consisting of particles no one of which exceeds eight inches in its greatest dimension. Use masonry rubble obtained from demolition work if it meets this requirement. Place fill material in layers each of 12-inch maximum thickness, compact each layer and fill voids in each lift with approved coarse sand.
5. Correct subsidence in filled areas by placing and compacting additional fill.
6. The Engineer may waive the requirement to fill cellar voids where cellar structures will be subsequently excavated for construction.

3.03 REMOVAL OF STREETCAR TRACKS, PAVEMENTS, SIDEWALK, CURBS AND GUTTERS:

A. Removal of Streetcar Tracks:
1. Regardless of depth, totally remove and dispose of rails, slot rails, yokes, switches, turnouts, ties, manholes, concrete and masonry encasements, cables, insulators and other related parts and accessories of track installation located within boundaries drawn two feet outside outer rails. Remove materials within such boundaries horizontally and from existing street grade to yoke encasement subgrade, vertically. In double track installations, remove materials in intervening space between inner rails of each track.
2. Known locations of streetcar tracks are shown.
3. Remove streetcar tracks as necessitated by the work and as directed, whether tracks are shown or encountered during excavation.
4. Transport from the site removed or excavated track accessories or parts thereof which will become the property of the Contractor.
5. Methods of removal and disposal will be at the Contractor's option, subject to approval and meeting the requirements of the Construction Sequence and Maintenance of Traffic Schedule.

B. Demolish pavement, sidewalks, curbs and gutters within demolition area shown to underside of pavement and dispose of resulting debris. Remove and salvage stone curbing where shown. Dispose of six-inch granite curb.

C. Fill resulting excavations, holes and depressions to existing grade or alternative grade as shown, using fill material conforming to requirements of Section 02320.

D. Adequately drain resulting surfaces.

3.04 DISPOSAL:

A. Remove debris resulting from demolition work to locations outside Authority's right-of-way.

B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.

C. Do not burn debris at demolition site.

END OF SECTION

SECTION 02230

SITE CLEARING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This Section includes the following:
   1. Protecting existing trees and vegetation to remain.
   2. Removing trees and other vegetation.
   3. Clearing and grubbing.
   4. Topsoil stripping.
   5. Removing above-grade site improvements.
   6. Disconnecting, capping or sealing, and abandoning site facilities in place.
   7. Disconnecting, capping or sealing, and removing site facilities.

B. Related Sections include the following:
   1. Demolition: Section 02220.
   2. Topsoil, seeding and sodding: Section 02920.
   3. Landscaping: Section 02930.
   4. Construction Facilities and Temporary Controls- Div 1

C. Definitions
   1. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than *2 inches* in diameter; and free of weeds, roots, and other deleterious materials.
   2. Facility: Utility structures and system components belonging to utility company including service lines which are used to provide service to utility's customers and product which these facilities convey.
   3. Utility: Company, agency, owner or operator of facility concerned.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Documentation:
      a. Permits and releases from each owner of property where debris will be deposited absolving the Authority of responsibility in connection with such disposal.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Requirements for satisfactory soil materials are specified in Division 2 Section "Earthwork."

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

B. Standard Wood Tree Guards: As shown on W.M.A.T.A. Standard Drawing ST-C-16, consisting of the following:
   1. Wood posts: Two inches square.
   2. Wood stringers: Two inches by four inches.

C. Standard Chain-Link Tree Guards: As shown on W.M.A.T.A. Standard Drawing ST-C-16, consisting of the following:
   1. Chain-link fencing: Nine gauge, two-inch mesh.
   2. Posts: 2.7 lbs. per foot “H” or 1-1/2 inches inside diameter.
   3. Brace rails: 1-5/8 inches outside diameter.
   4. Stretcher bars: 1/4-inch by 3/4-inch.

D. Temporary Enclosures and Wrapping: Contractor's option.

E. Tree Wound Paint: Standard bituminous product.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Provide erosion-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways

C. Locate and clearly flag trees and vegetation to remain or to be relocated.

D. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.02 TREE PROTECTION

A. Erect and maintain temporary enclosures or wrappings around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove enclosures or wrapping when construction is complete.
   1. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
   2. Do not permit vehicles, equipment, or foot traffic within drip line of remaining trees.

B. Protect trees shown on the drawing with standard wood or chain link tree guards.

C. Nurture protected and replaced trees, shrubs and plants during the period of this Contract.

D. Do not excavate within drip line of trees, unless otherwise indicated.

E. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
   1. Cover exposed roots with burlap and water regularly.
   2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
   3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
   4. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

F. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
   1. Employ a qualified arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
   2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

3.03 UTILITY FACILITIES

A. Locate, identify, disconnect, and seal or cap off facilities indicated to be removed.
   1. Owner will arrange to shut off indicated facilities when requested by Contractor.

B. Existing Facilities: Do not interrupt facility service to building connections occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Engineer not less than two days in advance of proposed facility interruptions.
   2. Do not proceed with facilities interruptions without Engineer's written permission.

C. Excavate for and remove underground facilities indicated to be removed.

3.04 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
   3. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
   4. Use only hand methods for grubbing within drip line of remaining trees.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated
   1. Place fill material in horizontal layers not exceeding 8-inch loose depth, and compact each layer to a density equal to adjacent original ground.

3.05 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Strip surface soil of unsuitable topsoil, including trash, debris, weeds, roots, and other waste materials.

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C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Limit height of topsoil stockpiles to 72 inches.
   2. Do not stockpile topsoil within drip line of remaining trees.
   3. Stockpile surplus topsoil and allow for respreading deeper topsoil.

3.06 REMOVAL OF TREE BRANCHES:

A. Remove tree branches which extend over structure neat lines and are less than 20 feet above top of rail or existing surface whichever is higher.

B. Remove tree branches which create a hazardous condition.

C. Remove branches so as to present balanced appearance of tree.

D. Treat scars resulting from removal of tree branches with heavy coat of tree wound paint

3.07 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

3.08 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off Owner's property.

B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.

C. Burning and burying debris on site is prohibited.

END OF SECTION

SECTION 02240

DEWATERING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies general dewatering systems for control of groundwater and removal of surface water during construction.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM:
      a. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
      b. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
      c. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
      d.

B. Qualifications:
   1. For mined earth tunnels, have the design, implementation, evaluation, and maintenance of the dewatering system under the supervision of a specialist with a minimum of five years experience in responsible control of work similar to that proposed.

C. Design Criteria:
   1. Provide dewatering system which will reduce hydrostatic pressure and lower groundwater levels below excavation levels excluding mined tunnels, as necessary for safe and proper prosecution of the work and which will result in obtaining stable, substantially dry subgrade for prosecution of subsequent operations.
   2. For mined earth tunnels, provide dewatering system which will reduce hydrostatic pressure and control groundwater in soil surrounding each tunnel to prevent the following:
      a. Heaving of the invert, hazardous seepage, and flow of soil in tunnel face.
      b. Loss of ground and surface subsidence.
   3. For mined earth tunnels in pervious soils, lower groundwater to two feet below invert or reduce hydrostatic pressure to a point where tunneling proceeds without groundwater related delay and loss of ground.
   4. For mined earth tunnels where impervious soils extend above invert, lower groundwater level to two feet above top of lowest impervious soil layer or reduce hydrostatic pressure to a point where tunneling proceeds without groundwater related delay and loss of ground.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Working Drawings:
      a. Type of dewatering system proposed, showing arrangement, location and depths of proposed system, complete description of equipment and materials to be used, installation procedure, well and piezometer

development procedures, maintenance plan for dewatering system and piezometers, standby equipment and standby power supply (if required), and proposed location of points of discharge of water and settlement measuring procedure.

b. Obtain approval of jurisdictional agencies prior to installation of system.

2. Documentation:

a. Observe and record average flow rate and time of operation of each pump used in dewatering system. Provide appropriate devices, such as totalizing flow meters for observing flow rates.Provide interior dewatering well drop tube and exterior filter piezometer to observe and record operating levels and filter levels. Submit data on approved form and in approved format during period dewatering system is in operation.

b. Observe and record elevation of groundwater in the piezometers, including those previously installed, on approved form and in approved format, during the period that dewatering system is in operation. Sound depth to bottom of each piezometer monthly to ensure that soil particles are not building up in standpipe. Submit observation records promptly, regularly and as directed.

c. During dewatering, make observations daily. After dewatering levels have stabilized, observations frequency may be reduced as approved.

d. Submit maintenance schedule for piezometers and dewatering system. Record and submit maintenance records for each piezometer and dewatering well or dewatering system component weekly or as approved

e. Provide drill logs and installation details of all dewatering system components, and piezometers, 24-hours after installation.

1.03 JOB CONDITIONS:

A. Subsurface Conditions:

1. Reports of subsurface investigations are available as listed in the General Requirements.

B. Permits:

1. Prior to discharging water, obtain permit from jurisdictional agency.
2. Control discharge of water in accordance with the General Requirements, if specified.

C. Responsibilities:

1. Design and install dewatering system to accomplish groundwater control as specified.
2. Monitor, and report as required, discharge from dewatering system to determine if water quality meets the requirements of jurisdictional agency. Modify dewatering system as necessary to meet the requirements of jurisdictional agency.
3. Measure to determine if movement occurs in adjacent areas by dewatering operations; take approved measures to minimize movement and prevent damage to affected properties, buildings, structures, utilities or facilities. Establish criteria for acceptable tolerances.
4. Take measures to prevent damage to properties, buildings, structures, utilities and facilities resulting from groundwater pumping.
5. Modify system if it causes, or threatens to cause, damage to properties, buildings, structures, utilities or facilities.
6. Repair as approved, damage, disruption or interference to properties, buildings, structures, utilities or facilities resulting from dewatering operations.
7. Contract Drawings may designate locations where lowering of groundwater will not be permitted.

8. Locations of dewatering system elements and piezometers may be adjusted in field to suit job conditions, as approved.
9. Operate dewatering system without interruption until directed otherwise.

D. Coordination with Other Contractors:
1. The Contract Specifications govern requirements for access to areas outside Contract limits.
2. Coordinate installation and operation of dewatering system and piezometers with others concerned and with other Authority contractors if applicable.
3. If an adjoining Authority contract requires installation of portions of the adjoining contract dewatering system or piezometers within Contract limits, allow access for installation.

PART 2- PRODUCTS

2.01 PIEZOMETERS:

A. See Soil & Geological Standard Drawing Piezometer Details as shown.

B. Piezometer construction shall use ASTM-specified materials and procedures (D2466, D1785, and D2564) .

PART 3 - EXECUTION

3.01 SURFACE DRAINAGE:

A. Intercept and divert surface drainage away from excavations, piezometers and dewatering wells by use of dikes, curb walls, ditches, pipes, sumps or other means.

B. Design surface drainage systems to prevent erosion.

C. Remove surface drainage system when no longer required.

D. Remove debris and restore site to original conditions.

3.02 DRAINAGE OF EXCAVATED AREAS:

A. Provide and maintain ditches of adequate size to collect surface and subsurface water and divert it into sump for draining or pumping into channels or storm sewers, as approved.

B. Install settling basins, tanks or other approved apparatus as necessary to bring the discharge into compliance with permit requirements.

C. When no longer necessary, backfill and seal drainage ditches, sumps and settling basins with approved material.

3.03 DEWATERING:

A. Coordinate dewatering installation to prevent conflict with other construction activities.

B. Install dewatering system in accordance with approved drawings and procedures. If site conditions require modification of the dewatering system, implement modifications to achieve specified design criteria prior to excavation.

C. Demonstrate by approved methods that discharged sand content from each well meets the design criteria specified above under Quality Assurance.

D. Discharge subsurface water clear of the work area.

E. Maintain continuous and complete effectiveness of the installation through regularly scheduled maintenance of well screens, pumps, piezometers, electrical and piping systems.

F. Maintain water level so that no damage to structure can occur.

G. During backfill operations, the extent of dewatering may be reduced when approved, provided water level does not result in uplift pressure in excess of 80 percent of downward pressure produced by weight of structure and backfill in place.

H. At locations of piezometers in mined earth tunnel sections, reduce water level to specified criteria at least 48 hours in advance of tunnel excavation.

I. Maintain dewatering operations until permanent tunnel lining has been installed.

3.04 PIEZOMETERS:

A. Prior to dewatering operations, install piezometers at locations shown or as approved and to the depths shown or approved.

B. Verify installed piezometer tip elevation. Reinstall piezometers which do not comply with requirements at no additional cost to the Authority.

C. 48 hours after completion of each piezometer installation, prove proper functioning of piezometer by performing Falling Head Tests. Submit test records within 24 hours of test completion.

D. While dewatering system is in operation, prove continued proper functioning of each piezometer by performing rising head tests. Submit test records within 24 hours of test completion.

E. Take static water level readings prior to energizing dewatering system. Submit water level readings within 24 hours of observation.

F. Operate dewatering system so that groundwater level in piezometers is maintained continuously within prescribed limits.

G. Protect and maintain piezometers in good operating condition until completion of Contract.

H. Replace promptly any piezometer or dewatering well that is damaged or destroyed.

I. Terminate piezometer readings when approved.

3.05 PORTIONS OF SYSTEM TO BE LEFT IN PLACE:

A. When specified, leave portions of dewatering system in place.

3.06 PORTIONS OF SYSTEM TO BE REMOVED:

A. Upon completion of Contract, remove piezometers and well casings, unless otherwise specified, to a depth of two feet minimum below ground surface.

B. Backfill voids, well and piezometer casings with bentonite-cement grout.

C. Backfill remaining space with compacted earth and restore ground surface to its original condition.

END OF SECTION

SECTION 02255

UNDERPINNING, SUPPORT AND RESTORATION OF STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies underpinning, supporting and restoring of structures.

B. Definitions:
   1. Underpinning: Permanent supporting structure designed to transmit foundation loads to lower bearing levels necessary to securely maintain structure being underpinned. Also includes temporary support necessary to safely perform underpinning work and restoration of structure upon completion of work.
      a. Temporary support: Construction required and designed to support structures during underpinning or other construction work.
      b. Restoration: Correction by repair or replacement of structure which is damaged, removed or altered by the Contractor in furtherance of his operation equivalent to condition existing prior to start of Contract work unless otherwise shown or specified.
   2. Structure categories:
      a. Category 1 structures: Structures for which underpinning is necessary and has been designed.
      b. Category 2 structures: Structures which, because they are likely to be affected by construction operations, the Contractor has the option of supporting temporarily, underpinning or both. The decision rests solely with the Contractor who is entirely responsible for results.

C. Related Work Specified Elsewhere:
   1. Grading, excavation and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Support of excavation: Section 02260.
   4. Decking: Section 01530.
   5. Piles: Section 02460.
   6. Concrete work: Sections 03100, 03200 and 03300.
   7. Structural steel: Section 05120.
   8. Geotechnical instrumentation: Section 02291.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM: D1056, D1149, D1692.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Working Drawings:
      a. Verify by field investigation foundation loads, locations, sizes and conditions of existing structures and footings requiring underpinning and temporary protection.

b. Prepare working drawings showing method, staging and necessary details, including computations for construction of underpinning and temporary support of each structure on which work is to be accomplished as well as method of transferring structural load to piles.

c. Have drawings and computations certified by a registered professional engineer who is licensed to practice in the jurisdiction where the work is to be performed and who is qualified to substantiate extent and design of underpinning work.

2. Documentation:

a. Submit written understandings with each structure owner with owner's signature signifying his agreement.

1.04 JOB CONDITIONS:

A. Consents, Permits and Approvals:

1. The Authority will obtain necessary rights from owner for Contractor to occupy construction areas for Category 1 Structures as shown.

2. The Contractor is responsible for obtaining in his own name, other agreements, rights, permits and consents necessary to effect underpinning work, which are to provide for and constitute agreement as to interdependent unitized system of underpinning support, when such system is feasible in the Contractors' opinion. Obtain permits required by jurisdictional agencies. Permits to name property owner and the Authority as co-applicants, when applicable, and the Contractor as their agent. Transmit copies of these instruments to the Engineer before starting work on each affected structure.

3. Additional requirements for permits, consents and approvals are contained in the General Provisions. Where plans for existing structures are available, they may be reviewed as specified in the General Requirements.

B. Responsibilities:

1. Maintain safety, stability and integrity of structures of whatever nature regardless of location which may be affected by the work.

2. Repair damage to structures caused by work necessary to restore structures to condition existing prior to start of work.

3. Perform underpinning operations in accordance with applicable codes and regulations of the jurisdictional agencies.

4. Perform underpinning operations with qualified personnel under continuous supervision of a registered professional engineer experienced in such work.

C. Coordination with Structure Owners:

1. Prior to starting work on structure, confer with owner or his authorized representative and obtain concurrence with underpinning procedures and sequence of operations including:

a. Means of access to the construction area.

b. Permitted areas of operations.

c. Time restrictions for performance of work which may disturb occupants.

d. Scheduling of time and durations of outages of utilities and other services to premises as well as of operation of systems within premises.

2. Notify the Engineer three days prior to intended conferences with owner.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Piling: Section 02460.
B. Concrete: Section 03300, Class 3500 or better.
C. Reinforcement: Section 03200.
D. Structural Steel: Section 05120.
E. Vibration-Isolation Materials:
   1. Closed-cell neoprene isolation board conforming to ASTM D1056, Grade 2C5.
   2. Self-extinguishing when tested in accordance with ASTM D1692.
   3. No cracks after exposure to air containing 100 ppm of ozone for 100 hours at 104F with samples under 20 percent strain tested in accordance with ASTM D1149.
   4. Water absorption: Not exceeding one percent by weight.

F. Bonding Adhesive: As recommended by the vibration-isolation material manufacturer.

PART 3 - EXECUTION

3.01 DETECTION OF MOVEMENT:

A. In accordance with the General Requirements, provide, install and maintain monitoring equipment to detect horizontal or vertical movement of structures as specified in Section 02291.

B. Inscribe or firmly affix on each column, pile cap, or wall to be underpinned or supported and at additional locations directed by the Engineer, visual methods of determining movements. Method used is optional but to be capable of being read to within 0.005 foot.

C. Take readings daily or more often if necessary during progress of underpinning or support operations and for a period of four weeks after completion of such operations. Frequency of readings may be reduced at specific location(s) with prior approval.

3.02 TEMPORARY PARTITIONS AND CLOSURES:

A. Build where shown and as required by property owner, closed, dustproof, weatherproof and burglarproof temporary partitions and closures of suitable materials to isolate work site from remainder of the structure. Comply with local building code requirements.

B. Provide emergency exits, with appropriate hardware.

C. Provide temporary protection against dust and damage from underpinning operations.

D. Remove temporary protective installations upon completion of work and restore area to original condition.

3.03 INSTALLATION:

A. Excavation:
   1. Excavate underpinning pits in accordance with Section 02320.
   2. Support excavated surfaces in accordance with Section 02260.
   3. Provide and maintain protective fencing and decking in accordance with Section 01530.
   4. Dewatering: In accordance with Section 02240.

B. Underpinning:

1. Perform needling, shoring, cribbing and posting as necessary to ensure that movements damaging to the structure do not occur prior to and during underpinning operations.
2. Place dry pack mortar, concrete and reinforcing steel in accordance with Sections 03100, 03200 and 03300.
3. Install structural steel shapes in accordance with Section 05120.
4. Install piling where shown in accordance with Section 02460.
5. When jacking piles, establish adequate controls to detect movement of structure being underpinned. Maintain suitable equipment and methods continuously available to contain movement should it occur.
6. Remove obstructions encountered when installing steel shell piling by drilling or spudding. Blasting is prohibited.
7. Test installed piling where shown and take remedial action necessary to obtain loading.
8. Use underpinning piles for underpinning purposes only, unless approved.
9. Transfer structural load to piles in accordance with approved procedures.
10. When transfer of loading has been completed and approved, clean pits of foreign matter.

C. Vibration Isolation:
1. Place vibration-isolation material where shown using boards supplied in lengths sufficient for one-piece installation. Apply bonding adhesive at rate recommended by manufacturer of board.

D. Backfill:
1. Place concrete backfill to limits shown.
2. Place and compact earth backfill in accordance with Section 02320.

E. Restore ground and building surfaces to their original condition.

F. Remove debris and construction materials. Leave site in a neat presentable condition.

END OF SECTION

SECTION 02260

SUPPORT OF EXCAVATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies support for cut-and-cover, open-cut excavation, trench excavation and shafts.

B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Maintenance, support and restoration of utility facilities: Section 02270.
3. Decking: Section 01530.
4. Rock reinforcement: Section 02420.
5. Drilling: Section 02431.
6. Concrete reinforcement: Section 03200.
7. Cast-in-place structural concrete: Section 03300.
8. Steel bars, steel strand, anchorages, couplings for ground anchors, grout: Section 03415.
9. Structural steel: Section 05120.
10. Grounding and bonding of soldier piles: Section 16060.
11. Geotechnical instrumentation: Section 02291.

C. Contractor's Options:
1. System of support to consist of soldier piles and lagging, sheet-piling or slurry-trench concrete walls, secured in place by means of bracing members such as wales, struts, shores and ground anchors. Other methods of support permitted only when approved.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standard and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. API: 13A, 13B-1.
3. ASTM: A36, A709, A722.
4. EPA.

B. Design Criteria:
1. Design support of excavation in accordance with design criteria shown and specified. Criteria are the minimum acceptable.
2. Design component members of system to support temporary decking system, earth and rock pressures, unrelieved hydrostatic pressures, utility loads, applicable traffic and construction loads and other surcharge loads. Use loading combinations shown. Prepare design for staged removal of bracing to suit sequence of concrete placement.
3. Design support system for nonpenetration of station and entrance surfaces visible to public. Temporary penetration permitted only where location of penetration is eventually to be hidden by elements such as acoustical panels or similar items

4. Design sheeting and bracing for sides of excavations for underground structures in a manner permitting safe and expeditious construction of permanent structures, minimizing movement or settlement of the ground and preventing damage to adjacent buildings, structures and utility facilities. Locate and design the bracing system such that it will not interfere with the reinforcement and construction of the permanent structure.
5. For support systems in which struts are installed between opposite sides of the excavation, design and construct support of both sides to obtain comparable rigidity.
6. Choose location of soldier piles to allow for expected deviations from true line during driving procedure without encroaching on future permanent structures.
7. Approval of Contractor's plans and methods of construction does not relieve the Contractor of the responsibility for adequacy of support.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Working Drawings:
      a. Details, arrangement and method of assembly of proposed system, including construction sequence.
      b. Method of preloading and bracing.
      c. Elevations and sections showing full excavation depth from top grade to bottom of soldier piles or subgrade, whichever is deeper.
      d. Loads for various stages of bracing removal and concrete placement.
      e. Anticipated equipment load.
      f. Maximum design load to be carried by various members of support system and preloads.
      g. Depths below main excavation to which support system will be installed.
      h. Methods of resolving difficulties arising from misalignment of soldier piles exposed during excavation and criteria for implementation of those procedures.
      i. Methods of controlling and monitoring vibrations caused by driving of soldier piles to prevent damage to structures and utility facilities.
      j. If proposed support system includes tieback anchors, show geologic profile or section for which each anchor is intended, design load for full depth of the excavation, maximum design and proof load and criteria proposed for deformations under proof loads.
      k. Ground anchors and rock bolts:
         1) Prior to starting work, submit support system tieback and rock bolt details including design calculations, installation and load test procedures, grouting materials, grouting methods and detailed working drawings of the proposed rock bolt system.
         2) Show geologic profile or section for which each ground anchor or rock bolt is intended and design load of ground anchor and rock bolt for full excavation condition.
      l. Include design calculations and maximum theoretical deflections of support members.
         1) The maximum allowable deflections of support members are as follows:

Soldier beams	1/2-inch
Walers	1/4-inch

         This does not include the movement of support due to creep in tieback.
      m. Include existing utility facilities. After checking their locations by field investigations, revise drawings to show actual locations of facilities, location of excavation supports, interference with proposed work and measures proposed to overcome such interferences.

2. Documentation:
   a. Where proposed system of tieback anchors or rock bolts projects beyond vertical projection of property lines shown onto adjoining property, obtain permission of owner in writing.
   b. Submit copies of permits with drawings.
   c. Calculations:
      1) Design calculations as applicable.
      2) Do not proceed with work prior to approval.

1.04 JOB CONDITIONS:

A. Provision for Contingencies:
   1. Monitor performance of components of support system, both vertical and horizontal movement in accordance with Section 02291, at regular intervals not to exceed three days.
   2. Provide contingency plan or alternative procedures to be implemented if unfavorable performance is evidenced.
   3. Keep on hand materials and equipment necessary to implement contingency plan.

B. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to utility owner.

C. If existing utility facilities interfere with proposed method of support, modify or relocate such facilities with the approval of the appropriate utility owner. If relocation of the utility is not possible, obtain Engineer's approval for field changes to the approved support scheme of the excavation.

D. Do not splice elements of support system unless approved.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Steel Sheet Piles: Continuous interlocking type with cross section selected for intended use.

B. Cast-In-Place Structural Concrete: Section 03300, Class 3500 unless otherwise shown.

C. Timber Lagging: Structural grade, minimum allowable flexural stress of 1,100 psi.

D. Concrete Reinforcement: Section 03200.

E. Structural Steel: Section 05120; ASTM A36 or ASTM A709, Grade 36, minimum.

F. Rock Bolts: Section 02420.

G. Ground Anchors:
   1. Steel bars: ASTM A722 and Section 03415.
   2. Steel strand: Section 03415.

H. Anchorages and Couplings for Ground Anchors: Section 03415.

I. Grout: Section 03415.

J. Bentonite Powder: API 13A.

K. Other Materials: Those best suited for intended use, and as approved.

2.02 MIXES:

A. Lean Concrete: Portland cement and mineral or soil aggregate proportioned so that concrete retains its shape during excavation operations.

B. Concrete for Slurry Trench Walls:
1. Tremie concrete of 3500 psi strength or higher if necessitated by design, with the following additional requirements:
   a. Minimum cement factor: Seven bags per cubic yard.
   b. Water-cement ratio: As necessary for strength and durability.
   c. Sand proportion: As necessary to produce optimum results.
   d. Rounded gravel aggregate: 1-1/2 inch maximum.
   e. Slump: Six inches plus-or-minus one inch.
   f. With water-reducing or fluidizing agents as necessary.
2. Submit mix design for approval.

C. Bentonite Slurry:
1. Stable suspension of powdered bentonite, or equal, and natural silts and clays in water.
2. Density: 64 pcf minimum, 85 pcf maximum.
3. Marsh funnel flow rate: 40 seconds minimum, 80 seconds maximum viscosity.
4. Fluid loss: 25-cc maximum in 30 minutes.
5. pH: 7.0 to 11.0
6. Shear strength:
   a. By shearometer: 1.4 to 10 N/M.
   b. By fan viscometer: 4.0 to 400 N/M.

PART 3 - EXECUTION

3.01 SHEETING, SHORING AND PILING:

A. Install soldier piles by driving, preboring or other pre-excavation methods. Drive soldier piles only in those areas where shown or approved. Install piles vertically within tolerance of one foot per each 100 feet for full depth of each pile.

B. Where piles are installed by preboring or other pre-excavation methods, take appropriate measures to stabilize excavation to preclude loss of ground.

C. Provide prebored holes for soldier piles adequate to accommodate pile section shown on approved working drawings. Extend hole to necessary depth below top of subgrade.

D. Carry bottom of support system to depth below main excavation, adequate to prevent lateral movement. In areas where additional excavation is required below main excavation subgrade, make provisions to prevent movement of main excavation supports.

E. Multiple-Layered Horizontal Bracing:
1. At locations where top of weathered bedrock is above the subgrade of main excavation, install soldier piles so that tips are at least two feet below top of subgrade.
2. At locations where top of weathered bedrock is five feet or more below subgrade of main excavation, install soldier piles so that lower tip is at least five feet below bottom of excavation.

3. If weathered bedrock is encountered at elevation between subgrade elevation and five feet below subgrade, install soldier piles so that lower tip is five feet below subgrade or two feet into rock, whichever is higher.

F. After seating soldier piles in pre-excavated holes, encase piles with Class 3500 concrete up to lowest point of excavation adjacent to pile location. Fill remainder of hole with lean concrete, completely encasing pile.

G. Use timber lagging, steel sheeting or precast reinforced concrete members secured in place for sheeting of excavations.

H. Follow excavation closely with placement of sheeting and lagging. Do not allow maximum height of unsheeted or unlagged face of excavation to exceed five feet in rock or predominantly clayey soils and three feet in sandy soils.

I. Do not permit height of unlagged face to exceed 15 inches if water flows from face of excavation or if soil in face moves toward excavation area.

J. Carefully perform excavation for installation of sheeting to minimize formation of voids. Separate sheeting members only to extent necessary to permit packing behind them.

K. Pack behind sheeting as installation progresses to establish tight contact between excavation face and sheeting. Pack openings between sheeting members with straw or other suitable material to allow free drainage of water without loss of soil or sand packing.

L. If unstable material is encountered during excavation, take suitable measures to contain it in place and prevent ground displacement which may cause damage.

M. Maintain sufficient quantity of material on hand for sheeting, shoring, bracing and other operations for protection of work and for use in case of accident or emergency.

N. Support System For Vertical Shafts Which Penetrate Soil/Rock Interface:

1. Soldier piles:

a. If shaft excavation is supported by soldier piles, locate piling at least five feet in a horizontal direction from outer face of shaft wall. Install lower tip of piling at least ten feet below top of unweathered bedrock.

b. Procedure for establishing tip elevations:

1) Make three pilot core borings at equal spacing along soldier pile line. Borings may be washed through overburden, but must be cored through bedrock to a depth of 20 feet into unweathered rock as determined by the Engineer. Advance holes in rock by rotary drilling methods and recover 2-1/8 inch diameter (NX) size rock cores using Series M double-tube core barrel. Drill in conformance to applicable portions of Section 02431. Place cores in wooden boxes as specified in Section 02431 and deliver to storage site as directed.

2) Install soldier piles to obtain tip elevations established by the Engineer's examination of coring results.

3) For shafts where pilot core borings indicate top of unweathered bedrock varies by more than three feet in elevation, set tips of soldier piles at least ten feet below lowest point of top of unweathered bedrock.

4) In drilling soldier pile holes, use equipment capable of penetrating hard igneous and metamorphic rock that has an average unconfined compressive strength of six to eight kips per square inch and that may reach even greater values in some locations.

2. Ring beams and lagging or liner plate:
   a. If shaft excavation is supported by ring beams or liner plates, install rings or liner plate to at least ten feet below average elevation of top of unweathered bedrock, which will be determined by the Engineer from examination of the rock in the advancing excavation.

3.02 SLURRY WALLS:

A. Slurry Trench Equipment:
1. Use equipment capable of removing from trench foreign materials embedded in soil as well as natural materials, including boulders, where necessary. Arrange equipment to permit free vertical passage of slurry within trench and to prevent development of suction or pressure.
2. Furnish trench inspection tools adequate to ensure that trench has been excavated to dimensions shown on approved working drawings and that cuttings and foreign material have been removed.
3. Use slurry mixing equipment capable of producing, with mechanical agitation, a stable suspension of bentonite and water. Transport slurry to panels by temporary pipe line or other approved methods.
4. Furnish slurry circulation equipment to provide circulation and agitation of the slurry throughout full depth of excavated panels. Do not agitate slurry by air
5. Use slurry reclaiming equipment which will remove detrimental quantities of excavated material from slurry to ensure use of clean slurry in trenches. Recirculate reclaimed slurry to trenches in a continuous operation regardless of slurry density. Monitor slurry and control its capability of retaining solid particles in suspension.

B. Field Quality Control:
1. Make tests on samples of in-place slurry to determine density, viscosity, filtration and sand content in accordance with API 13B-1.
2. Maintain quality of bentonite slurry compatible with soil characteristics of trench walls.

C. Construction:
1. Perform preparatory work to discover, protect, maintain, relocate and restore utility facilities and other obstructions in vicinity of slurry walls.
2. Construct slurry trench walls by displacement of bentonite slurry with tremie concrete.
3. Construct walls of reinforced concrete or plain concrete embedded with structural steel. Where soldier piles are used in construction of walls, it is permissible to consider piles as reinforcement.
4. Provide sufficient embedment of walls below subgrade of excavation to prevent loss of ground due to piping under wall or lateral movement of wall.
5. Use construction methods ensuring that slurry materials employed during trench excavation and placing of tremie concrete are contained and controlled to prevent leakage and spillage of slurry and excavated materials into basements, vaults, utilities and other facilities.
6. Excavate slurry wall trenches in panels of width and depth shown on approved working drawings with maximum panel length of 18 feet. Reduce panel length when excavating adjacent to facilities sensitive to settlement.
7. Maintain level of slurry in panels no more than five feet below top of trench during excavation operations and until tremie placement is essentially completed.
8. Progress construction with no less than one unexcavated panel and one tremie-filled panel with concrete cured at least 72 hours, between two slurry panels under active excavation.
9. Keep slurry circulated or agitated during drilling and excavating and immediately prior to concreting. Continuously maintain slurry requirements even during

nonworking periods and stoppages. If stoppage occurs in the operation causing slurry in panel to remain uncirculated and unagitated for more than 24 hours, backfill panel until operation can be resumed.

10. Place concrete by tremie methods either by gravity flow or by pumping. As soon as possible after placement of concrete is commenced, position bottom of pipe not less than five feet below upper surface of concrete being placed and maintain it in this position throughout operation. Equip tremie pipe with bottom valve or other device to prevent mixing of slurry with concrete inside tremie pipe. Aluminum pipe is prohibited.
11. Inspect trenching in the presence of the Engineer prior to concreting. Ensure that settled cuttings and excavated material have been removed.
12. Start placement of concrete in panels within 12 hours after completion of panel excavation and proceed continuously until concreting is completed.
13. When wales are used, obtain tight bearing between wales and wall and ample bearing area with wedges and dry pack for load transfer.
14. Preload braces at each level to computed maximum compressive force to be encountered at that level. Base calculations of this computed force upon pressure diagrams shown. Take into consideration increased strut loads that may develop because of removal of bracing as structure is built.
15. Accomplish preloading by approved procedures. Transfer load by jacking applied symmetrically to braces without introducing eccentricity.
16. Introduce jacking load into braces immediately after each tier of braces has been installed and before excavation has progressed more than two feet below bottom of bracing tier. Make provision to fix preload into each brace by shim plates, wedges, blocking or other approved device.
17. After concrete invert slab has been placed and attains sufficient strength to receive loads from slurry walls, remove tiers of bracing above invert level, provided the following conditions exist:
    a. Remaining tiers are capable of resisting total load calculated from trapezoidal pressure diagrams shown.
    b. Calculated deflection of the walls between tiers of bracing, assuming forces indicated by the trapezoidal pressure diagrams, does not exceed 1/2 inch.
18. Construct tight joints between adjacent pours of concrete in slurry wall to minimize loss of fines from retained earth. Take necessary care to accomplish this in terms of properly excavating trench and cleaning abutting face of hardened concrete or surfaces of structural members if used. Provide approved method of water stopping.
19. Seal leaks encountered in walls as excavation progresses, if leaks are of sufficient size to permit penetration of fines and loss of ground. Procedures may include grouting outside or through wall.
20. Dispose of unsuitable excavated material and debris in accordance with Section 02320.
21. Dispose of slurry waste offsite by means of sealed tanks and in accordance with EPA regulations.

3.03 PRIMARY SUPPORT:

A. Use wales, struts, tieback anchors and rock anchors as necessary to provide primary support of excavation faces retained by soldier piles, sheeting, sheet piles or concrete slurry walls. For excavation depths greater than eight feet, primary support or supports are required.

B. Provide struts with intermediate bracing as needed to enable them to carry maximum design load without distortion or buckling.

C. Provide diagonal bracing as needed to maintain stability of system.

D. Include web stiffeners, plates or angles as needed to prevent rotation, crippling or buckling of connections and points of bearing between structural steel members. Allow for eccentricities caused by field fabrication and assembly.

E. Install and maintain primary support members in tight contact with each other and with surface being supported.

F. Design primary support members to support maximum loads occurring during excavation or removal stages.

G. Preloading:

1. Except for ground anchors and slurry wall bracing, preload primary bracing members including struts, shores, wales carrying axial load, and similar members at installation to 50 percent of design load, which for this purpose is maximum load that bracing member will have to carry. Preload tiebacks and slurry walls as specified for those installations.
2. Use procedures that produce uniform loading of bracing member without appreciable eccentricities or overstressing and distortion of members of wall system.
3. Make provisions for permanently fixing load in each member using steel shims or wedges welded into place.
4. Accomplish preloading by jacking support in place against soldier piles or wales.
5. Do not use wooden wedges to preload bracing member.
6. Include in preloading system means to determine within five percent amount of preload induced into bracing members.

H. If decking beams are not required or if decking beams are not designed for support of excavation loads, install uppermost tier of bracing at vertical distance of not more than six feet below top of excavation.

I. Install tiers of primary support with no greater vertical distance between them than 16 feet

J. Reduce maximum vertical distance to 12 feet at locations where ground movement and settlement must be minimized to prevent damage, where shown and as directed.

K. Excavate to no more than two feet below point of support about to be placed. Install support and preload immediately after installation and prior to continuing excavation.

3.04 SUPPORT SYSTEM WITH TIEBACKS:

A. Install tieback system in accordance with approved working drawings. Install anchorage in soil no closer than a plane extending upward at an angle of 45 degrees to the horizontal from outer limit of lowest depth of excavation.

B. Stress tiebacks to proof loads equal to 140 percent of maximum design load and maintain proof load for 30 minutes prior to reducing to design load. Reject tiebacks which lose more than five percent of proof load during 30-minute period.

C. Apply proof loads in increments of five tons at one-minute intervals and provide means to measure load application within accuracy of plus-or-minus five percent.

D. After reducing tieback load to design load, encase anchors in grout maintaining design load until anchors are fixed in place.

E. In transfer of loads from jacks to support system, use fixation method which will limit load loss to no more than five percent of design load.

F. Provide and maintain convenient access and appropriate means to accomplish these observations.

G. Preliminary And Creep Tests On Tiebacks:
1. Reapply proof loads equal to 140 percent of design load at each level of support in excavation on first installation on each side of excavation at horizontal intervals not exceeding 500 feet and wherever there is significant difference in soil in which tiebacks are installed.
2. As specified for proof loading, apply proof loads in increments of five tons at one-minute intervals. Provide means to measure load applications with an accuracy of plus-or-minus five percent of design load. Maintain proof load for 24 hours prior to reducing it to design load.
3. Make records of axial movement with incremental applications of load as well as amount and time of load fall-off with no pumping of jack or axial movement during 24-hour period that proof load on tieback is maintained. If during 24-hour period axial deformation of tieback system exceeds 0.02 inch or decrease in jack pressure without pumping is more than five percent after correcting for temperature changes during the test period, redesign tieback system to satisfy requirements.

H. Rock Bolts:
1. Tension rock bolts to their design load as approved to permit checking of each loading by the Engineer.
2. If grouted rock bolts are used, after loading has been approved, pressure-grout each permanent rock bolt in place using methods and equipment which will ensure elimination of air from bolt hole.
3. If fully resin-encapsulated bolts are used, use slow-setting resin to allow Engineer sufficient time to approve loading prior to gelation.

I. Vertical Support System With Tiebacks:
1. nstall piles or other vertical support system members incorporated in a system utilizing tiebacks so that they are capable of resisting vertical components of tieback loads without significant settlement during excavation and construction.
2. Install vertical support members so that settlements will not be caused by construction. In general, install members to be end bearing in stratum below maximum depth of excavation and capable of carrying total vertical loads without assistance of skin friction at depth of excavation.

3.05 LAGGING:

A. Unless otherwise shown or specified, provide timber lagging of three inches minimum thickness where it spans soldier piles placed at distances five to seven feet on centers and for excavation depths up to 25 feet. Increase minimum lagging thickness to four inches for excavation below 25 feet in depth.

B. For other conditions and types of lagging, submit design details for approval.

3.06 TRENCH EXCAVATION:

A. Perform sheeting, shoring and bracing for trench excavation for utility facilities and other purposes in accordance with specified safety requirements.

B. Provide sheeting, shoring and bracing for trench excavation in subgrade of subway excavation to prevent movement of main excavation support system.

3.07 SUPPORT OF EXCAVATION AT INTERFACES:

A. Design, construct, maintain and remove all or parts of support system at limits of the Contract at interface with the Authority's adjacent contracts, as may be necessitated by construction schedules and sequence of operations of respective contracts.

B. In the event excavation is commenced at an interface prior to the commencement of excavation on adjacent contract, design, construct and maintain end support system making provisions as follows:
   1. Install near face of cofferdam on line separating contracts. Allow no part of support system to project into the next contract except thickness of supporting wall, e.g. soldier piles and lagging, and tiebacks if approved.
   2. Provide support system adequate to support backfill and restoration loads with installation of a reasonable bracing system by adjacent contractor during excavation for his contract.
   3. Design and construct support system so that it will be supported against vertical settlement when adjacent contractor removes lower portion of the cofferdam to effect connection of structures at juncture of two contracts.

C. If excavation has commenced on adjacent contract at interface prior to excavation on this Contract, make provisions as follows:
   1. Coordinate removal of such portions of cofferdam which have been installed in adjacent contract and support and maintain remainder as necessary to effect juncture of contracts.

3.08 FIELD QUALITY CONTROL:

A. Tests:
   1. Where system of tiebacks or rock bolts is proposed in conjunction with or in lieu of struts, bracing and shores, undertake approved number of on-site tests to demonstrate adequacy of tiebacks or rock bolts for typical subsurface conditions.
   2. Conduct tests and obtain approval prior to use of tieback system for excavation support.
   3. The Engineer may furnish and install certain instruments to monitor performance of tieback or rock-bolt system.

B. Remove components of support system which inadvertently penetrate or encroach on permanent structure without endangering stability of support.

C. Welding: In accordance with Section 05120.

3.09 REMOVAL OF SUPPORTING SYSTEM:

A. When removing support of excavation system, wholly or in part, do not disturb or damage adjacent buildings, structures, construction or utility facilities. Fill voids immediately with lean concrete or with approved backfill compacted to density specified in Section 02320.

B. During strut removal stages, design soldier piles or slurry walls for increased vertical spacing of supports. For the removal of the first level support immediately above the invert slab, the slab can be considered a support for the soldier piles or slurry walls if it is poured directly against the sheeting and shoring and the invert slab is in place for at least 48 hours and is adequate to safely support the support of excavation, adjacent structures and the works. Leave support immediately above top of intermediate structure element, such as walls, slabs, or other horizontal members, until they are placed and are in place for at least seven days and are adequate to carry the loads from the support of excavation and other loads imposed on them. Leave support immediately above top of roof slabs of structure in place for at least seven days after placement of roof slab concrete.

C. Remove other supports above roof structure only after backfill has been placed and compacted to required density to within three feet of bottom of support.

D. Except as specified below, remove supporting system to a depth of six feet below surface. Remove supporting systems of intersections of streets and at temporary access ramps to a depth of eight feet.

E. Where top of Authority structure extends into six-foot or eight-foot limit, remove adjacent supporting systems to a depth flush with top of the Authority structure or one-foot below surface, whichever is greater. Increase removal depths where necessary to accomplish work in this Contract.

F. Remove material of supporting system from site immediately.

END OF SECTION

SECTION 02270

MAINTENANCE, SUPPORT AND RESTORATION OF UTILITY FACILITIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies protecting, supporting, maintaining and reconstructing existing utility facilities affected by construction, including but not limited to the following:
   1. Storm, sanitary and combined sewer facilities.
   2. Water distribution and service
   3. Gas distribution and services.
   4. Electric light and power facilities and services.
   5. Telephone, telegraph and GSA communication facilities and services.
   6. Police and fire alarm systems.
   7. Traffic signals and street lighting, temporary and permanent.
   8. Steam distribution facilities.
   9. Parking meter installations.

B. Related Work Specified Elsewhere:

1.	Selective Demolition:	Section 02220.
2.	Grading, excavating and backfilling:	Section 02320.
3.	Dewatering:	Section 02240.
4.	Support of excavation:	Section 02260.
5.	Sanitary Sewer:	Section 02535.
6.	Storm Sewer:	Section 02635
7.	Water distribution system:	Section 02515.
8.	Ducts, manholes and handholes:	Section 02585.
9.	Removal and restoration of existing facilities:	Section 02205.
10.	Concrete reinforcement:	Section 03200.
11.	Concrete:	Sections 03100 and 03300.
12.	Decking:	Section 01530.

C. Work by Others:
   1. Gas distribution and services: Gas company will do its own work.

D. Definitions:
   1. Facility: Utility structures and system components belonging to utility company including service lines which are used to provide service to utility's customers and product which these facilities convey.
   2. Utility: Company, agency, owner or operator of facility concerned.
   3. Abandoned: Use of facilities shown as existing has been discontinued by the owners and operators. Demolish or remove such facilities to extent they conflict with proposed work.
   4. To be abandoned: Particular facility will be removed from operation and/ or replaced by other facilities after written notice has been received that service is no longer required. Maintain service for as long as required, including temporary support, rerouting, substitution of temporary facility or other measures, as directed by the Engineer. Demolish or remove such facilities to extent they conflict with proposed work.
   5. Maintenance: Ensuring continuous and satisfactory service during construction.
   6. Proposed facility:
      a. New facility constructed and, if necessary, temporarily supported in place, by the Contractor.
      b. Temporary facility constructed, supported in place and ultimately removed and new facility constructed, by the Contractor.
      c. New facility constructed as part of rapid transit construction.

7. Temporary facility: Facility provided by the Contractor in lieu of existing or proposed facility, to ensure continuity of service.
8. Maintain complete-in-place: Support and maintenance in serviceable condition, of existing facilities during construction, which may include constructing permanent support, temporary support or other measures necessary to maintain continuous service of existing facility.
9. Expose and maintain existing cables and replace ducts and manholes: Remove existing duct and manhole structures, construct temporary manholes, place existing cables in split conduits and replace spare ducts with whole conduit. Maintain this system during construction. Reconstruct permanent concrete manholes and encase conduits in concrete as specified. Cables for electric power and telephone facilities shall be exposed, separated and supported under supervision of electric power and telephone companies.
10. Maintain service and replace:
    a. Construct new facility in same location and support it in place.
    b. Provide temporary facility and ultimately remove it, and construct permanent replacement facility in its original location.
    c. Temporarily support original facility and ultimately replace it with new facility.
11. Remove and replace: Remove existing facility without providing temporary replacement and reconstruct new facility in same location during execution of contract.
12. Local Jurisdictional Authority: Agency responsible for acceptance and approval of work on storm, sanitary and water distribution facilities.
13. Salvage: Remove and store material and equipment for reuse in this or other Authority contracts.

1.02 SUBMITTALS

A. Schedule of Work on Utility Facilities:
1. Submit to the Utilities and the Engineer a detailed sequence of work, with starting and ending dates for each interruption of utility services, and method of coordination for shutoff, capping and continuation of utility services.
2. Give notice at least two weeks prior to date of intended commencement of operations to parties having surface, subsurface or overhead structures in the construction area.Provide copies of notices to the Engineer.
3. Do not commence work until written approval has been received from the Utility and the Engineer.

B. Record Documents:
1. Show actual location of existing facilities, interference which these facilities present to new work, proposed method of proceeding with actual construction and details of proposed support systems.
2. Show actual location of settlement measurement points for facilities as indicated on the drawings. Submit copies of readings and measurements within 24 hours after such readings are taken.
3. Prior to construction, submit two copies of records of inspection of sewers, one copy to local jurisdictional authority and one copy to the Engineer. On completion of tunneling and cut-and-cover and prior to paving or other construction over sewers, submit to local jurisdictional authority and the Engineer one copy each of the inspection records of sewers, including video-tape records of television inspections and coordinated logs, photographs and other records as specified by local jurisdictional authority for visual walk-through inspections. Obtain and submit a written approval and acceptance from local jurisdictional authority of the inspection records of preconstruction and post-construction conditions of affected storm and sanitary sewers.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, and Standards: Comply with codes and regulations of the jurisdictional authorities, published standards of owning utility agency, and ASTM: C136.

B. Inspection Of Sewers:

1. Employ a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to local jurisdictional authority to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter. Submit to Local jurisdictional authority for prior approval one sample of the cassettes to be used.
2. Conduct preconstruction and post-construction inspections under conditions as nearly identical as practical and using the same company.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with utilities who are furnishing materials for the work to determine availability, locations and required methods of storage and care of materials prior to incorporation into the work.

B. Transport store and handle materials in accordance with the requirements of the utilities.

1.05 PROJECT CONDITIONS:

A. Existing Facilities:

1. Locations of existing facilities shown are plotted from available records; however, these locations are not guaranteed.
2. Verify by field investigation and “Miss Utility” utility locating service, locations of facilities within and adjacent to limits of project which may be affected by construction operations. Avoid damage or disruption of facilities during operation.
3. Upon encountering existing facility which is not shown or upon ascertaining that facility differs from that shown, determine ownership, use and disposition of such facility and proceed as follows:
   a. If facility is abandoned or is to be abandoned, perform necessary work for either condition as specified.
   b. If facility is to remain in service, perform support and restoration work in accordance with these Specifications and the CHANGES article of the General Provisions.

B. Temporary Service:

1. Do not interrupt facility service to building connections unless permitted in writing by Engineer, and then only after arranging to provide temporary service as required..
2. Notify the Engineer and the Utility of damage to facilities caused by construction operations. Repair such damage, except that damaged cables will be repaired or replaced only by the Utility.
3. Provide access for inspection of facilities and for emergencies involving utility services as specified in Section 01530.
4. Permit free and clear access to utility personnel for purposes of inspection, maintenance, providing additional service and construction of new facilities.
5. When approved working or shop drawings show temporary facility provided for the Contractor's benefit, supply necessary materials and perform necessary work.
6. Pay utility directly if, as an aid to the Contractor's construction, the utility performs work not shown.
7. Items supplied by the utility companies are as listed and as shown.

1.06 Coordination:

A. Establish through the Engineer direct and continuous contact with respective utilities and cooperate with them in all phases of the work.

B. ontact utility early enough to allow them sufficient time to accomplish the work. Give special consideration to lead times required for cable work. Provide schedule of utility relocation to the utility to permit coordination with Authority's construction sequence.

C. To locate buried telephone cables, call the local telephone company's Buried Cable Location Service at least 48 hours prior to starting excavation.

D. Comply with printed standards and practices of utilities available from the Engineer.

E. Aerial facilities shown to be relocated by others will be relocated by facility owner. The Contractor is responsible for coordinating relocation work with utility owner as far as possible in advance of required time of relocation. A minimum three-month lead time is required by utility owner when facility serves only one utility. When facility to be relocated is shared by more than one utility agency or when a street light is included in the relocation, a minimum four-month lead time is required

PART - PRODUCTS
2.01 MATERIALS:

A. Refer to individual Division 2 Storm, Combined And Sanitary Sewer, Water Distribution and Services, Ducts and Manholes Sections for pipe, tubing, fittings and appurtenances, and for joining and installation methods.

B. Refer to individual Division 3 Concrete and Reinforcement Sections for materials and installation methods.

C. Sand Backfill Around High Voltage Conduits And Pipes:
1. Thermal Resistivity Value (RHO) of not more than 70 and the following sieve analysis when tested in accordance with ASTM C136:

Sieve Size	Percent Passing
4	94 - 100
8	80 - 90
16	60 - 80
30	35 - 60
50	31 - 35
100	3 - 13
200	1 - 5

2. The power company, through the Engineer, will inform the Contractor of approved sources for this material.

PART 3 - EXECUTION
3.01 Salvage:

A. Salvage and clean material shown to be salvaged.

B. Maintain adequate records and storage facilities for salvaged items as specified in the General Requirements. Make available for inspection a detailed record including signed vouchers and receipts.

C. Reuse salvaged items after inspection and approval for reuse has been given by the Utility

D. Return salvaged materials which are not reused to the Utility.

3.02 SETTLEMENT OR MOVEMENT:

A. Where settlement or movement monitoring system is shown, comply with the following:
   1. Provide series of settlement measurement points along each facility and make regular readings to detect movements.
   2. Use approved painted marks, metal marker plugs or pins as settlement measurement points.
   3. Prior to subsurface work, make initial survey to establish elevations of installed settlement measurement points utilizing permanent, established bench marks outside 100-foot line.
   4. Take readings weekly on settlement points until completion of this Contract. Take readings daily during work which may affect facilities.
   5. Make readings to an accuracy of 0.01 foot.
   6. Take immediate remedial measures to correct conditions causing settlement or other movement and to repair damages thus caused.

3.03 EXCAVATION AND BACKFILLING OF UTILITY TRENCHES:

A. Excavate and backfill utility facility trenches in accordance with Sections 02320, 02240 and 02260.

B. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to facility owner.

3.04 SURFACE RESTORATION:

A. Remove pavements, sidewalks, lawns, landscaping , curbs and gutters where necessitated by utility trenches in accordance with Section 02220.

B. Replace pavements, sidewalks, curbs and gutters in accordance with Section 02205.

C. Place temporary pavements where necessitated by sequence of operations.

D. Replace lawns and landscaping in accordance with Sections 02920 and 02930.

E. Provide erosion control measures to prevent erosion or displacement of soils and discharge of sediment bearing water or airborne dust from the site.

3.05 UNSAFE AND UNSUITABLE UTILITY STRUCTURES:

A. General Requirements:
   1. If upon exposure, condition or location of facility to be supported in place is found to be unsafe for maintenance or support, replace or reconstruct facility as required after receiving prior approval of the Engineer and Utility Owner.
   2. Maintain continuity of existing utility facilities. Protect, support, relocate and reconstruct such facilities, regardless of jurisdictional control.

B. Electric, Communication and Similar Type Facilities:
   1. If structures containing electrical, communication and similar types of cables shown to be maintained complete in place are found upon exposure to be incapable of being maintained in place because of condition, location or both, replace such structures with timber enclosures or split ducts after prior approval of the Engineer and the utility owner.
   2. When service box, manhole or conduit structure containing electrical or communication cables is broken away, replace it immediately with temporary structure having facilities for racking and supporting cables equivalent to existing facilities.

3. Exercise care when working in vicinity of telephone structures containing coaxial cable which cannot withstand movement.
4. Give timber enclosures one interior and one exterior coat of fire-retardant paint of type specified by owners and operators.
5. Replace temporary timber enclosures with permanent structures in accordance with details shown and restore facilities to the satisfaction of the Engineer and utilities prior to completion of work. Remove materials of temporary nature after completion of permanent installation.

C. Procedures for payment of costs of work on unsafe and unsuitable utility structures are governed by the CHANGES article of the General Provisions.

END OF SECTION

SECTION 02291

GEOTECHNICAL INSTRUMENTATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the design, installation, maintenance, and removal of geotechnical instrumentation to monitor soil, rock, and structure movements during construction. This section also includes specifications for reading, analyzing, and reporting instrumentation monitoring results.

B. Design Criteria:
   1. Provide a system of geotechnical instrumentation which will allow monitoring of soil, rock, and excavation support elements, as well as adjacent structures and utilities to ensure safety and stability, confirm design assumptions, and provide a basis for establishing compliance with Contract requirements.

C. Definitions:
   1. Geotechnical Instrumentation - Any device designed to determine change in the position or state of stress of soil, rock, and structures.
   2. Instrument Monitoring - The procurement of data obtained from the repeated optical, mechanical, or electronic observations of geotechnical instruments.
   3. Frequency of Monitoring - The number of readings obtained from a geotechnical instrument with respect to time.
   4. Initial reading- The first stable reading set obtained after instrument installation, but prior to excavation, to which all subsequent readings will be compared.
   5. Threshold Limit Values Level 1 and Level 2 - Designer-specified limits for geotechnical instrumentation which if exceeded require (1) notification of the Authority and increased monitoring frequency and (2) implementation of the contingency plan.

1.02 QUALITY ASSURANCE:

A. Comply with codes and regulations of the jurisdictional authorities.

B. Permits - Prior to instrumentation installation obtain any permits from the responsible jurisdiction and pay permit costs and any associated fees at no additional cost to the Authority.

C. Qualifications of Personnel:
   1. Instrumentation Selection, Design, Layout, and Data Analysis shall be performed by a registered Professional Engineer specializing in geotechnical engineering with 5 years experience in soil stability and geotechnical design
   2. Instrumentation installation shall be performed under the supervision of qualified technicians with at least one year experience in the installation of instruments of the type specified.
   3. Instrumentation monitoring shall be performed by qualified technicians with at least one year experience in the reading of instruments of the type specified.

D. Continuously maintain all geotechnical instrumentation in proper working condition and within manufacturer's specifications. Immediately repair or replace malfunctioning equipment. All instrumentation readout devices to be periodically tested and recalibrated within schedule as recommended by the instrument manufacturer or as approved by the Authority..

1.03 SUBMITTALS:

A. Submit the following for approval prior to proceeding with work:
   1. Type of instrumentation system proposed, showing arrangement, location and depths of proposed system.
   2. Manufacturer's literature including descriptions and installation recommendations for all instruments, software, and read-out devices proposed for use.
   3. Instrumentation installation schedule and monitoring schedule.
   4. Resumes listing the qualifications of the Professional Engineer and Technicians specified in 1.02.C.

B. Instrument Installation Data:
   1. Record of installation details including date and time of installation, general soil condition at instrument site, adjacent construction activities, and remarks of unusual conditions observed during installation.
   2. As-built location and elevation of installed instruments including coordinates and distance referenced to Outbound track centerline. Supply location data within 48 hours of instrument installation.

C. Instrumentation Monitoring Data:
   1. Analyzed data to be submitted on forms approved by the Authority within 48 hours after instrument monitoring. Supply copies of field notes if requested.
   2. Immediately report to the Authority movements exceeding Level 1 limits.
   3. Shift Reports of Construction Activities:
      a. For each shift in which work is taking place, submit a report within 24 hours containing the following:
         1) Detailed excavation and tunneling status at time of instrument reading.
         2) Excavation subgrade elevation and tunnel face station at time of instrument reading.
         3) Incidents of ground loss, groundwater flow, excavation support instability, or any other unusual event.
         4) General construction activity in the vicinity of the instruments.
         5) Duration and cause of delays to construction activities.
         6) Weather conditions.

D. Contingency Plans:
   1. Submit contingency plans to stabilize soil, rock, and structures affected by adverse movements detected by instrumentation. Submit contingency plans at least one month prior to start of excavation or tunneling. At a minimum, include the following:
      a. Names, telephone numbers, and locations of persons responsible for implementation of contingency plans.
      b. Materials and equipment required to implement contingency plans.
      c. Location onsite of all required materials and equipment to implement contingency plans.
      d. Step-by-step procedure for performing work involved in implementation of the contingency plans.
      e. Threshold limit Level 1 and Level 2 values for all instruments.
      f. Clear identification of objectives of contingency plans and methods to measure plan success.

1.04 JOB CONDITIONS:

A. Do not disclose to third parties or publish monitoring data without the approval of the Authority.

B. The Authority may monitor any geotechnical instrument at any time. Provide and facilitate access to instruments for the Authority.

C. The instrumentation monitoring data shall be continuously reviewed and interpreted by the responsible instrumentation specialist.

D. During construction, additional instrumentation may be required beyond that proposed in the initial design. Modifications to the instrumentation plan, including proposed instrument locations, may be required due to site conditions and instrumentation results.

E. Ensure that all instrumentation installations are continuously protected and are not damaged by construction activities, including blasting. Replace or repair as necessary any instrument damaged by construction activities or adverse soil, rock, or structure movement.

PART 2- PRODUCTS

2.01 INSTRUMENT TYPES:

A. Specify instrument types and locations in accordance with design criteria indicated in Section 1.01 B.1. and as approved by the Authority.

PART 3 - EXECUTION

3.01 INSTRUMENT INSTALLATION SCHEDULE:

A. Install and obtain initial readings for all surface instrumentation prior to excavation, chemical grout operations, or dewatering activities, in accordance with approved schedule. In areas to receive chemical grout, delay installation of instruments which might be damaged by chemical grout until completion of this activity.

B. For all instrumentation located within excavated areas, install and obtain initial reading as soon as practical after excavation or passage of tunnel heading in accordance with approved schedule.

3.02 INSTRUMENT LOCATIONS:

A. Install instruments as close as practical to locations submitted and approved. Actual conditions in field may require location adjustment. Obtain Authority approval for location adjustments.

B. After instrument installation, submit reports showing location and installation details of each instrument as specified in Section 1.03.B.

C. Ensure that all proposed instrument locations will not result in damage to utilities or other structures. Coordinate proposed instrument locations with Miss Utility and any other affected owners prior to instrument installation.

3.03 INSTRUMENTATION MONITORING:

A. Initial Reading:
   1. At time of initial reading, verify that instrument is functioning and has been installed in accordance with contract specifications and manufacturer's recommendations.
   2. Replace at no additional cost to the Authority any instrument which does not meet specification requirements.

3. Obtain at least three separate and complete sets of initial readings on each instrument which yield consistent results.
4. Should inconsistent initial readings be obtained on any instrument, reread until correct and repeatable readings are obtained.

B. Monitoring Frequency:
1. Monitoring frequency to be in accordance with schedule submitted and approved as specified in Section 1.3 A.3.
2. Instrument readings which show significant change from previous readings shall be reread immediately.

C. Instrumentation Monitoring Threshold Values:
1. Instrumentation system design shall establish threshold limit values for each instrument.
   a. Level 1 Limit values if exceeded require notification of the Authority within 24 hours and notification of individuals listed within the contingency plan. Monitoring frequency of affected instruments which exceed Level 1 limit will be increased to frequency as approved within the contingency plan.
   b. Level 2 limit values if exceeded require immediate notification of the Authority and implementation of the contingency plan. Instruments which exceed Level II limits will be monitored continuously until stability is achieved.

3.04 INSTRUMENT PROTECTION, MAINTENANCE, AND REPLACEMENT:

A. Protect and maintain instruments. Divert surface water from instrument covers. Flush debris from instrument installations. Maintain access to all instruments.

B. Provide barriers as required to protect instrument.

C. Install and maintain instruments and instrument access covers in a manner which protects workers and ensures public safety.

D. Repair or replace damaged instruments within 5 days at no additional cost to the Authority.

3.05 REMOVAL OF INSTRUMENTS:

A. Prior to final acceptance of work and subject to Authority approval, remove and dispose of all instrumentation.
1. Remove surface instrument installations to 2 feet below ground surface. Backfill voids and casing with cement grout.
2. Restore ground surface to original condition.

B. Fill holes in masonry with portland cement mortar. Restore structure surfaces to original condition.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY THE DESIGNER.

ENDNOTES:

1. The Designer must specify the level 1 and 2 threshold values before finalizing the contract-specific specifications.

END OF SECTION

SECTION 02320

GRADING, EXCAVATING AND BACKFILLING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies grading, excavating and backfilling for structures and utility facilities.

B. Related Work Specified Elsewhere:
1. Removal of existing construction and facilities: Section 02220.
2. Clearing and grubbing: Section 02230.
3. Dewatering: Section 02240.
4. Support of excavation: Section 02260.
5. Underpinning, support and restoration of structures: Section 02255.
6. Maintenance, support and restoration of utility facilities: Section 02270.
7. Rock tunneling: Section 02410.
8. Earth tunneling: Section 02415.
9. Rock reinforcement: Section 02420.

C. Definitions:
1. Grading: Shaping earth and rock through the removal or filling of earth and rock materials.
2. Earth Excavation: Excavation of materials of whatever nature, except rock as defined below.
3. Rock Excavation: Excavation of material in place which cannot be loosened or broken down by ripping using earth excavating equipment and which requires blasting or rock excavating equipment for its removal.
4. Approved Material: Earth which meets specified measurable requirements for use as embankment, fill or backfill.
5. Surplus Excavated Material: Approved excavated material which is not used in embankments or as fill on site.
6. Unsuitable Material: Material which does not meet specified requirements for use in situ or as embankment, fill or backfill and is prohibited for use in the work.
7. Authorized Excavation: Excavating to neat lines and limits shown and specified; excavating unsuitable material.
8. Unauthorized Excavation: Excavating materials which would otherwise be left in place; excavation which is not specified as authorized excavation, such as excavation beyond neat lines and bottoms of footings as shown.
9. Excess Excavation: Excavating materials beyond or below cross section shown, as well as unavoidable over breakage in rock.
10. Controlled Low Strength Materials (CLSM): Fill.

B. Salvage:
1. Materials shown to be salvaged in accordance with Section 02205 and the General Requirements.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and the additional requirements as specified for each:
1. Samples:
a. Submit sample 21 days in advance of desired date of approval. Two one-cubic-foot samples are required of each material proposed for fill, backfill and embankments.

b. Obtain, identify and ship soil and aggregate samples in accordance with ASTM D75.

2. Documentation:
   a. Permits for disposal of excavated material:
      1) Obtain written permits and releases from owners of property where material will be deposited.
      2) Each permit and release from each property owner will absolve the Authority from responsibility in connection with such disposal of the material.
   b. Blasting plan:
      1) Submit a blasting plan in accordance with Section 02410.
   c. Plan for tunneling or jacking of utility facilities:
      1) Prior to tunneling, submit a tunneling plan.
         (a) Include in the plan the location of the facility, the method of construction, the types of equipment and the procedures proposed.
         (b) Procedure for field determination of soil bearing capacity, including description of the equipment to be used, and any calibration curves for the various soil types to be encountered, details of field test procedures, forms for reporting of test data/results and details of minimum number of tests required for each footing/base area

3. Certification:
   a. With samples of materials proposed for fill, backfill and embankment, submitcertified test reports of tests performed by an approved Independent Testing Agency for all tests required to demonstrate compliance with specified requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M147.
   3. ASTM: C33, D75 , D698, D2487, D2922, D3017, D4318.

1.04 JOB CONDITIONS:

B. Existing Drainage:
   1. Preserve, protect and maintain existing operable drains and sewers during grading operations.
   2. Keep excavations dry.

C. Blasting:
   1. Control blasting in accordance with Section 02410.
   2. Exercise care in drilling and blasting operations so that the remaining rock remains stable and overbreak is minimized. Use controlled blasting in areas where concrete for walls and arches of structures is to be placed against rock.

D. Accident Prevention and Safety:
   1. Perform work in accordance with specified safety requirements and PROTECTIVE DEVICES article of the General Requirements.

E. Location of Underground Facilities and Structures:
   1. Locations shown for utility facilities are approximate.
   2. Utility facility locations and site investigations are listed in the General Requirements.
   3. Contact Miss Utility to have utilities located before beginning excavation.

F. Toxic and Combustible Substances:
1. During excavation, provide detection and testing equipment and carry out necessary tests to detect the presence of toxic and combustible substances.
2. Take action to safeguard persons and property in accordance with the rules and regulations of the jurisdictional agencies and utility owners.
3. Promptly notify utility owners when problems concerning their facilities become apparent.

G. Ramps:
1. Construct temporary ramps as necessary to provide access to work area.
2. Locate such access ramps in Contractor's storage, operations and access areas or within excavation for subway structure and maintain traffic as specified.
3. Support ramp excavation in accordance with Section 02260.
4. When ramps are in use, station flag persons equipped with red flags at ramp entrances to keep unauthorized vehicles or persons from entering work area.
5. When work necessitating entrance or exit of vehicles via ramps is not being performed, protect entrances and exits of ramps by warning signs, barricades and fences in accordance with the General Requirements.
6. Upon completion of the work needing ramps, remove the ramps in accordance with Section 02260; backfill excavated ramp areas, if necessary.

H. Excavation Near Buildings:
1. Control excavation in areas near buildings or structures to maintain stability of buildings or structures. If underpinning is necessary, perform excavation work in accordance with Section 02255, so that condition of surrounding area remains unimpaired.

PART 2 - PRODUCTS:

2.01 MATERIALS:

A. Embankment, Fill or Backfill Materials:
1. Composition:
a. Well-graded soil-aggregate mixture, as defined by ASTM D2487, comprised of stone, gravel, sand, silt, clay or combinations of such materials.
b. Prohibited material: Organic matter, debris, cinders and frozen material.
2. Additional requirements:
a. Particle size: Four inches maximum, but not exceeding one inch within one foot of finished grade.
b. Liquid limit: Forty maximum, determined in accordance with ASTM D4318.
c. Plasticity index: Ten maximum, determined in accordance with ASTM D4318.
d. Maximum dry density: Not less than 100 pounds per cubic foot.

B. Select Material: AASHTO M147, with the following gradation requirements:

THIS SPACE NOT USED.

Sieve Designation	Percentage Passing By Weight
Two inch	100
One inch	70 - 95
3/8 inch	35 - 75
Size 4	25 - 60
Size 10	15 - 45
Size 40	10 - 30
Size 200	0 - 15

C. Pervious Material:
   1. Natural, clean, free draining sand conforming to the requirements of ASTM C33 except the following:
      a. Material passing Size 100 sieve not to exceed eight percent.
      b. Material passing Size 200 sieve not to exceed five percent.
   2. Drainage Material: Clean, crushed, rock, gravel, with 1-1/2 inch maximum particle size and maximum two percent by weight passing Size 4 sieve.
   3. Below concrete walks and slabs: ASTM C33, Size No. 67, except maximum two percent by weight passing Size 4 sieve.

D. Impervious Material:
   1. Silt-clay material minimum 35 percent by weight passing Size 200 sieve.
   2. Plasticity index: 11 minimum, determined in accordance with ASTM D4318

2.02 SOURCE OF MATERIALS:

A. Use materials for embankment, fill or backfill from this Contract if they meet specified requirements. If sufficient material meeting these requirements is not available from this Contract, obtain material meeting specified requirements.

B. Use only material whose quality, source and zone of placement in the fill have been approved.

C. Dress and shape borrow areas provided by the Authority to ensure positive drainage when borrow operations are completed.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. Use appropriate equipment in sufficient quantity and sizes to perform the work as specified and shown.

3.02 EARTH EXCAVATION:

A. Excavate in sequences and stages as specified, and in a manner which will not impair permanent or temporary structures, installations or surfaces.

B. Excavate to neat lines or set back lines for mixed face conditions and grades shown. If approved, slopes may be flattened as a matter of expediency.

C. Support sides of excavation as specified in Section 02260.

D. Protect, support and maintain utility facilities as specified in Section 02270.

E. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to the facility owner.

F. Control runoff so that water does not run through excavation area. Keep excavation free of water.

G. Remove excavated materials to fill, embankment, stockpile or disposal locations. Keep haul routes clean in accordance with the General Requirements.

H. Fill excess excavations with approved materials and compact as specified.

I. Unauthorized excavation for the purpose of obtaining materials for resale or for use at another job site is prohibited unless otherwise approved by the Engineer.

3.03 ROCK EXCAVATION:

A. Perform rock excavation to neat lines shown and so as to produce surfaces free of loose rock.

B. Install rock reinforcement in accordance with Section 02420.

C. Remove loose, semi-detached and unsound fragments from blasted surfaces. Remove standing water, debris, oil and other objectionable coatings from surfaces of rock upon or against which concrete or porous fill material is to be placed.

D. Repair shattered or loosened rock surfaces outside neat lines shown, which in the opinion of the Engineer would be detrimental to subway structure or would adversely affect subway drainage system.

E. Where directed, grout rock surfaces which have not been shattered but are naturally permeable.

F. Remove excavated rock to approved fill locations or disposal locations.

G. Fill excess excavation with concrete or other approved material.

H. If flowing or seeping water is encountered during excavation, install approved drainage system in accordance with Section 02240.

3.04 REMOVAL OF SUBSURFACE OBSTRUCTIONS:

A. Permanent Closure walls:

B. Prior to removal of parts of vaults or areaways which extend into Contract limits, build permanent closure walls where shown in such vaults or areaways to separate areas to be left intact from areas to be removed.
   1. Obtain the Engineer's approval of permanent closure wall design prior to its installation.

C. Remove vaults, areaways and foundation walls as shown.

3.05 EMBANKMENT, FILL AND BACKFILL:

A. Place embankment, fill and backfill in eight-inch loose layers, unless otherwise shown, for entire width so that each layer can be uniformly and properly compacted.

B. Avoid accumulation of large pieces of material at one location. Fill voids and interstices with finer materials.

C. In confined areas, use approved power-actuated compactors to achieve required density.

D. Prior to compaction, adjust moisture content of material within required limits by drying or watering either at material source or on fill.

E. Leave struts, braces, lagging and timber sheathing in place as long as needed to support excavation and adjacent facilities and structures.

F. Where utility facilities and structures are supported in place, use special equipment and techniques as required to achieve specified compaction under and around them.

G. Do not place backfill on subway structures until requirements for curing and waterproofing have been complied with and, if required, until test cylinders for particular structure indicate that concrete has attained specified compressive strength.

H. When backfilling against structures, place material approximately simultaneously on both sides of structures to equalize opposing horizontal pressures.

I. When backfilling on tops of structures, place material in six-inch lifts over full area.

J. Under concrete floor and other slabs on grade, place drainage material directly on prepared subgrade which meets density and elevation requirements. Compact with hand-operated plate-type vibratory compactor.

K. Prior to placing embankment against slope greater than one vertical to four horizontal, cut benches into existing slope. Height of bench not to exceed two feet unless otherwise approved.

L. Maintain embankment, fill and backfill in stable, well-drained condition.

M. Where approved, dispose of surplus excavated material by widening embankments and flattening slopes.

N. Where pervious material will be exposed to erosion, cover it with 12-inch layer of approved impervious material compacted in place.

3.06 COMPACTION ADJACENT TO STRUCTURES:

A. Compact embankment, fill or backfill materials within five feet of retaining walls, abutments or other structures using lightweight compactors.

B. Do not overstress structures.

C. Backfilling against new structures without approval is prohibited.

3.07 EXCAVATION OF UNSUITABLE MATERIALS:

A. Remove unsuitable materials from the site.

B. Replace unsuitable material with approved material and compact as specified.

3.08 PREPARATION OF GROUND AS SUBGRADE:

A. Where the subgrade is on original ground or in cut or where embankment or fill is less than one foot, fulfill compaction requirement for 12 inches minimum below final subgrade.

B. If necessary, scarify original ground and adjust moisture content prior to compacting.

3.09 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Construct finished subgrade to vary not more than 0.05-foot above or 0.10-foot below elevation shown.
   2. Complete embankment slopes to plus-or-minus 0.5 foot of slope line shown.
   3. Maintain moisture content of embankment, fill or backfill material within plus-or-minus three percent of optimum moisture content of material.
   4. Compact each layer of embankment, fill or backfill to 95 percent of maximum dry density as determined in accordance with ASTM D698, at moisture content within tolerance specified, except the following:
      a. From upper surface of fill or backfill to a plane 12 inches below subbase level of vehicular pavement, sidewalks, trackbeds and structural foundations to 100 percent of maximum dry density at moisture content within tolerance specified.
      b. In areas of 95-percent compaction where utility facilities are located in fill and are not supported on concrete cradles, compact material for a depth of one foot directly below bottom of facility to 100 percent of maximum dry density at moisture content within tolerance specified.

B. Test Method:
   1. Determine the maximum dry density and the optimum moisture content in accordance with ASTM D698.
   2. Determine in-place density and moisture content in accordance with ASTMD2922 and ASTM D3017 respectively, or other test methods acceptable to the Engineer.

3.10 TUNNELING FOR OR JACKING OF UTILITY FACILITIES:

A. Location of facility, method of construction, type of equipment and procedures: As approved.

3.11 FINISHING:

A. On completion of work, clean ditches and channels.

B. Slope and shape borrow areas to provide positive drainage.

C. Remove unsuitable and surplus excavated materials to locations outside the Authority's right-of-way.

D. Leave site in neat, presentable condition.

END OF SECTION

SECTION 02410

ROCK TUNNELING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the following:
   1. Rock tunneling for running sections, stations, pilot drifts through stations, side drifts, crossover and transition sections, vaults, adits, auxiliary tunnels, escalator ways and cross-passages.
   2. Tunnel linings.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Subway drainage system: Section 02625.
   4. Earth tunneling: Section 02415.
   5. Rock reinforcement: Section 02420.
   6. Drilling and pressure grouting for rock tunnels: Section 02431.
   7. NATM excavation (rock): Section 02411.
   8. Concrete work: Sections 03100, 03200 and 03300.
   9. Shotcrete: Section 03370.
   10. Structural steel: Section 05120.
   11. Epoxy injection: Section 07125.
   12. Bentonite slurry: Section 07170.
   13. Piping systems: Section 15205. *1

C. Definitions:
   1. Rock tunneling: Excavation of natural rock, which requires use of rock excavation methods, such as drilling and blasting, channeling, wedging or barring, or rock tunneling machines.
   2. Controlled blasting: Excavation of rock in which the various elements of the blast, i.e., hole size, depth, spacing, burden, charge size, distribution, delay sequence, are carefully balanced and controlled to provide a distribution of charge which will excavate rock to required contours with smooth surface to minimize overbreak, stressing and fracturing of the rock beyond the contour line. Smooth-wall blasting, presplitting, cushion blasting and line drilling are examples of operations included in the term controlled blasting.
   3. Initial support:
      a. Elements designed, furnished and installed by the Contractor for stability and safety during construction and not shown.
      b. To the extent elements of permanent lining shown are effective in providing initial support, such elements may be utilized to provide initial support. If permanent lining must be augmented by initial support to ensure stability and safety during construction, provide elements of such initial support.
      c. Elements of initial support may be in the form of additional rock bolts, shotcrete, plain concrete, reinforced concrete, timber or steel members which may be temporary or permanent if compatible with permanent lining shown. Plain or reinforced concrete may consist of elements such as wall girders, carrier beams or supplementary foot blocks for temporary posting. Timber may consist of elements such as posts, struts and cross beams. Steel members may consist of such elements as steel sets, straps, spiling,

crown bars, carrier beams, girders, brackets, posts, struts, shores or needle beams. Design and provide these or other alternative elements, singly or in combination, to ensure stability and safety during construction. Install initial support to transfer loads to rock so as to ensure stability and safety during construction.

4. Permanent lining: Tunnel lining elements and support as shown.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. Appendix G of the General Requirements: Geotechnical Design Report.
   3. MS: MIL-P-26915 (USAF).
   4. ASTM: C171, D638, D1304. *2
   5. ASTM: C171, D638, D1304, D1785, D2464, D2564. *3

B. Blasting Consultant:
   1. Engage the services of approved, qualified independent, professional blasting consultant to design, review, evaluate and modify blasting operations.

C. Allowable Tolerances:
   1. Steel rib bending tolerance:
      a. Conformance to true template:
         1) Wide-flange sections up to 14 inches deep weighing 150 pounds per foot: Rib segments to conform to true template at butt plates; intermediate points may depart from true template up to 3/8 inch, providing no point departs more than 1/8 inch from three-foot template section.
         2) Wide flange sections heavier than 150 pounds per foot: Intermediate departure not exceeding 5/8 inch from true template; deviation from three-foot template section not exceeding 3/16 inch.
      b. Bending curvature uniform.
      c. After bending:
         1) Outer flange will be permitted to droop 1/8-inch maximum toward inner flange for radii of bend equal to or greater than 14 times rib depth; 1/4-inch maximum droop will be permitted for radii of bend which are less than 14 times rib depth.
         2) Rib depth at not less than theoretical depth minus 1/4 inch.
   2. Steel rib fabrication tolerances:
      a. Chord, out-to-out of butt, foot plates or both measured on centerline of rib: Theoretical length plus-or-minus 1/16 inch.
      b. Face of butt or foot plates: Within plus-or-minus 1/16 inch of theoretical plane.
      c. Gap between ends of ribs and butt or foot plates prior to welding not exceeding 1/16 inch for at least 75 percent of cross sectional area of rib. Where gaps are in excess of 1/16 inch, fill by additional steel-shim welding.
      d. Tie rod holes in rib webs: Within plus-or-minus 3/8 inch of locations shown on approved shop drawings.
      e. Width or length of sheared plates: Within theoretical dimension plus-or-minus 1/8 inch.
      f. Center-to-center of bolt hole dimensions on butt or splice plates: Theoretical dimension plus-or-minus 3/64 inch.

g. Bolt hole groups in butt or splice plates after fabrication: Within plus-or-minus 1/16 inch of theoretical location regardless of variations in rib resulting from other tolerances.

h. Holes in butt plates welded to ribs: Within plus-or-minus 1/16 inch of theoretical location.

3. Precast-concrete segment tolerances: As shown.

4. Watertightness criteria: Section 03300.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Working Drawings:

a. Prior to using tunneling machines, submit drawings showing design, specification, method of operation and other pertinent data.

1) Drawings and pertinent data for shielded tunnel-boring machine (TBM). Show dust-suppression system. If precast-concrete tunnel-lining segments are used, show the following:

(a) That machine can develop forward thrust independently of installed precast-concrete tunnel lining, if this lining is to be used.

(b) That machine is equipped to handle and erect precast-concrete segments behind cutter head within tail shield, including auxiliary equipment necessary for erection.

(c) Descriptions, data or calculations of proposed facilities, equipment to be utilized and method of construction. Items include, but are not limited to, the following: Hoisting plant, tunnel ventilation, lighting and drainage; groundwater-control methods; temporary shafts, cuts, ramps and tunnels; breakouts; cross passages; bulkheads; details of initial support; details of placing concrete and erection procedures for the installation of precast-concrete tunnel lining.

b. For excavation of tunnels and stations, submit drawings, calculations, descriptions and specifications for the following:

1) Number, size, location, orientation and direction of excavation of drifts and benches including those excavated previously and temporary drifts.

2) Sequence and timing of excavating drifts and benches including stagger of advance of heading in adjacent drifts or benches and anticipated rate of advance.

3) Blasting program including length of round and charge distribution for each drift.

4) Initial support elements, including when and where they will be installed in relation to excavation plan and sequence and design calculation and assumptions.

5) Permanent lining elements relationship to initial support elements and to the plan and sequence of excavation and support.

6) Construction equipment and capacities.

7) Assumptions used in arriving at above items, including:

(a) Thickness and condition of various zones of rock, decomposed rock and overburden.

(b) Incidence, orientation and extent of rock discontinuities including foliation, joints, shears, fractures, faulting, folding,

depth and degree of weathering, condition of discontinuities (open, tightly closed, gouge-filled).

(c) Relationship of excavation and initial support to rock discontinuities.

(d) Design load conditions and design mechanical properties of rock and discontinuities used for determining initial support requirements.

(e) Stability of sidewall and vertical rock faces with respect to excavation dimensions, sequence and rock discontinuities.

(f) Groundwater.

2. Certification:

a. Certified test report of properties of electrical insulative coating.

3. Documentation:

a. Blasting plan:

1) Not less than 30 days prior to starting a new phase of work, submit the following data concerning proposed blasting operations:

2) Location, depth, area, anticipated neat lines and relationship to adjacent excavations and structures.

3) Diameter, spacing, burden, depth, pattern and inclination of blast holes.

4) Type, strength, amount in terms of weight and cartridges of explosives to be used in each hole, on each delay and total for each blast.

5) Distribution of charge in each hole and priming of each hole.

6) Type, sequence and number of delays, delay pattern; wiring diagram for blast; size and type of hookup lines, and lead lines; type and capacity of firing source; type, size and location of safety switches, lightning gaps.

7) Scaled range or distance used to calculate scaled range if blast will exceed vibration limits.

8) Stemming of holes and matting or covering of blast area.

9) Qualifications of person directly responsible for supervising loading of shot and for firing it.

10) Complete, maintain and submit permanent blast reports including logs of each blast. Complete reports after each blast to include the following:

(a) Date, time and limits of blast by station.

(b) Amount of explosives used by weight and number of cartridges.

(c) Total number of delays used and number of holes used for each delay period.

(d) On a diagram of approved blast pattern indicate each hole not drilled, drilled but not loaded, changes in spacing or in pattern of delays or in loading of holes.

(e) Total number of holes, maximum charge per hole and corresponding delay number.

(f) Evaluation of blast indicating tights, areas of significant overbreak and recommended adjustments for next blast.

b. Permits for disposal of excavated material:

1) Arrange for disposal of excavated materials at locations outside the Authority's right-of-way, and obtain written permits from owners of property where excavated material will be deposited.

2) Submit each permit and release from each property owner absolving the Authority from responsibility in connection with disposal of such material.
3) Details of temporary ventilation:
4) In the event it is planned to use equipment not covered by the SAFETY REQUIREMENTS article of the General Requirements, submit details of such equipment.
5) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.

a. Air-quality reports:
b. Daily reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in the working environment during construction.
c. Leak repair work plan:
1) Include proposed application methods, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
2) Submit prior to beginning leak repair work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Concrete: Section 03300, Class 3500; Class 2500 concrete backfill where specified for rock trench for track drain.

D. Contact Grouting: Section 02431.

E. Structural Steel, Ribs, Beams, Channels and Plates: Section 05120.

F. Bolts: ASTM A325, unless otherwise shown or specified.

G. Timber for Blocking, Lagging, Foot Blocks and Cribbing: Sound, well-seasoned, hardwood timber of rectangular cross section.

H. Track Drainage: Section 02625.

I. Porous Subgrade Material: Section 02625.

J. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectionable materials such as soft particles, coal and lignite particles or friable particles, graded from 1/4 to 3/8 inch in size.

K. Sand: Section 03300, fine aggregate, except 100-percent passing U.S. Standard Sieve Size 16.

L. Precast Concrete Tunnel Lining Segments: Section 02425.

M. Impervious Membrane: Polyethylene, ASTM C171, clear or opaque, 0.006-inch thickness.

N. Epoxy Injection Material: Section 07125.

O. Bentonite Slurry for Repair of Leaks: Section 07170.

P. Epoxy Mortar:
1. Two-component, solventless epoxy-resin system, with 100-percent solids, workable in temperature range of 50F to 60F when mixed with sand in specified proportions.
2. Epoxy-resin system: FX-775, Fox Industries, Incorporated; Sikadur 31, Hi-Mod Gel, Sika Chemical Corporation or approved equal.
3. Sand for use with epoxy resin: Three parts No. 16 sand to one part No. 90 sand. High-silica type, dry and bagged.
4. Add sand to epoxy paste as necessary to provide best workability characteristics up to one part sand per one part epoxy.

Q. Electrical Insulative Coating: Approved moisture-insensitive coating, 100-percent solids, containing no solvents for use on dry or damp concrete or steel surfaces, with the following additional requirements:
1. Properties:
   a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days.
   b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
   c. Dielectric constant: ASTM D1304 as follows:
      1) 60 Hertz: 3.4-3.5.
      2) 1,000 Hertz: 3.3-3.4.
   d. Power factor: ASTM D1304 as follows:
      1) 60 Hertz: 0.006-0.007.
      2) 1,000 Hertz: 0.03-0.04.
   e. Viscosity: 6,000 centipoises plus-or-minus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.
2. Primer: Zinc-rich primer, MS MIL-P-26915 (USAF) Type 1, Class B.

R. Hydrostatic-Pressure Relief System: *4
1. Plastic pipe: PVC, Schedule 40, ASTM D1785.
2. Plastic fittings: PVC, Schedule 40, ASTM D2464.
3. Solvent cement: ASTM D2564.
4. Galvanized steel pipe and fittings: Section 15205.

2.02 FABRICATION:

A. Fabricate steel supports in accordance with Section 05120.

B. The following operations are not required:
1. Portions of bearing members such as butt and foot plates, straightened, planed and connected after fabrication.
2. Grinding to remove nicks resulting from flame-cutting.
3. Planing and facing of sheared edges or bearing surfaces.
4. Subpunching or subdrilling of bolt holes.
5. Inspection of groove and fillet welds by other than visual inspection.

PART 3 - EXECUTION

3.01 TEMPORARY VENTILATION:

A. Provide, operate and maintain for duration of project temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities. Remove system from site when work is completed.

3.02 SAFETY REQUIREMENTS:

A. Perform work so as to minimize safety hazards and exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

B. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.

3.03 DISTANCE BETWEEN HEADINGS:

A. Maintain longitudinal distance of no less than 150 feet between two adjacent tunnel faces being simultaneously excavated unless otherwise shown or approved in writing.

B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that initial support in first tunnel is completely installed and is adequate to withstand construction of second tunnel.

3.04 DETECTION OF MOVEMENT:

A. In accordance with the General Requirements and as shown, install, maintain and make observations of a system of detection of vertical and horizontal movement of ground, tunnel support, permanent lining and utilities adjacent to the work.

B. Special Instruments:
   1. Provide instrumentation as specified and where shown.
   2. Provide such facilities as directed for monitoring these instruments and take appropriate action to arrest movement revealed by resulting observations.

3.05 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Excavate to accommodate tunnel cross section and minimum thickness of lining selected to within one inch of alignment and grade shown.
   2. When steel ribs are used for initial support, do not permit any portion of lagging except clips or bolts used to attach lagging to ribs to extend into tunnel within concrete design line as shown nor any portion of steel rib including bracing to extend further than three inches into concrete design line.
   3. Place cast-in-place tunnel concrete to the following tolerances:
      a. Tunnel lining:
         1) Departure of tunnel from line or grade shown as measured from working point of tunnel: One inch.
         2) Variation in thickness of lining at any point: Minus zero inch.
         3) Variation in internal diameter at any point: One inch.
      b. Invert: As specified in Section 03300.
      c. Safety walk: As specified in Section 03300.
   4. Install precast concrete segment lining to tolerances shown.

3.06 EXCAVATION:

A. Excavate to lines, grades, dimensions and tolerances as shown and specified to accommodate initial support and permanent lining.

B. Tunneling Machine:

1. When excavating with tunneling machine, use equipment which includes dust-control system with spray system and dust shroud. Keep intake end of fan suction line as close to machine as possible without interfering with other operations.
2. Use equipment which permits installation of initial support no further than ten feet from tail. Use hood if necessary. Install initial support in accordance with approved working drawings.
3. In order to exercise option for using circular permanent lining comprised of precast segments, excavate tunnel and erect the segments by means of TBM. If, during machine boring, material is encountered in reaches of tunnel that cannot be excavated satisfactorily by TBM, excavate such reaches by other approved methods. Provide necessary initial support and cast-in-place concrete permanent lining as shown for such conditions.

C. Air Quality:

1. Perform drilling and tunneling operations by methods and with equipment which will positively control dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.
2. Provide approved instruments for testing quality of tunnel atmosphere; take samples under working conditions at prescribed intervals. Submit results of the quality tests.

D. Drilling and Blasting:

1. Perform blasting in accordance with the General Requirements and approved blasting plan.
2. Have the blasting consultant design initial blasts as well as supervise and conduct test blasts, if required, until regular production controlled blast patterns are developed that produce desired rate of excavation while meeting requirements for vibration and air-blast control. Have consultant periodically, or when requested by the Engineer, review blasting operations and direct such changes in blasting operations as necessary to produce a controlled blasting operation meeting specified requirements.
    a. Before blasting within 50 feet of cured concrete, except shotcrete, submit and obtain approval of plan showing relative positions of concrete, area to be blasted and blasting technique to be employed.
    b. Protect concrete work and structures in vicinity of blasting by limiting size of blasts, by covering blasts and by other means until it is certain that there is no danger of damage by shock waves or flying rock.
    c. Use controlled blasting techniques. Modify blasting round as necessary to achieve best obtainable results and to keep vibrations and noise within limits specified.
    d. As excavation proceeds and immediately after each blast, test the roofs and walls; scale loose and shattered rock which is likely to fall. Carry out similar checks on previously excavated sections at least every 48 hours; recheck support system and tighten, lagging, blocking and rock bolts as necessary.
    e. When so directed, drill feeler or pilot holes no less than 1-1/2 inch diameter ahead of excavation to predetermine nature and condition of materials to be excavated. Number of holes, location, direction and length, minimum 15 feet and maximum 30 feet: As directed.
    f. Install initial support in accordance with approved working drawings.

E. Vibration and Air-Blast Control:

1. Control operations in accordance with the following:
    a. Peak particle velocity:

1) Not to exceed two inches per second (ips) measured in or at any adjacent existing structure outside limits of construction site.

2) Peak particle velocity at structural concrete not to exceed the following limits dependent on age of freshly-placed concrete and powder charge per delay:

Concrete Age	Maximum Peak Particle Velocity (ips)
Less than three days	0.2
Between three and seven days	2.0
Over seven days	4.0

3) Calculate values of maximum powder charge per delay permissible at specified intervals of distance between point of detonation and critical structure and submit for approval.

4) exceed 140-dB peak sound-pressure level measured at edges of shafts or portals of tunnels.

2. Peak particle velocity is defined as maximum of three velocity components of a vibration measured at any point in three mutually perpendicular directions by an appropriate instrument.

3. Peak sound-pressure level is the peak level measured on the A-scale of a standard sound-level meter at slow response.

4. The Engineer may make measurements to determine if the Contractor's operations are exceeding such requirements. This data will be available to the Contractor.

5. If data indicates that specified requirements are not being met, take necessary measures including reducing size of charge, covering or matting blasts to reduce noise and vibrations to acceptable levels.

F. Dispose of excavated materials as specified.

G. Drain excavated areas as necessary in accordance with requirements of Section 02240.

H. If initial support is necessary, keep its installation within three feet of excavated face; do not leave tunnel unsupported without full initial support for longer than three hours after excavation. Stabilize face if necessary.

3.07 STRUCTURAL STEEL SUPPORT FOR PERMANENT LINING:

A. Install structural steel supports true to lines and grades, blocked, braced and wedged against rock surface or against initial layers of shotcrete placed on rock surface.

B. Install supports as soon as possible after initial layers of shotcrete are placed or as soon as possible after exposing rock by excavation and as close to headings as work will permit.

C. For support at base of steel ribs, use steel foot plates resting on smooth bearing surface formed by precast concrete or low slump, dry-packed concrete.

D. Position joints to facilitate steel-rib installation as necessary and as approved.

E. Wedge and brace blocking and cribbing solidly between rock surface or initial shotcrete layer and steel supports. Check blocking and cribbing and retighten after every blast or more frequently as necessary to maintain it in a secure condition.

F. Use no greater amount of wedging, blocking, timber lagging and cribbing than necessary to support ground safely and to distribute load to structural-steel supports.

G. Do not cover more than 25 percent of rock surface abovespring line with wedging, blocking, timber lagging and cribbing nor more than 25 percent of projected rock surface of walls below spring line. 25-percent criterion applies along any 10 feet of horizontal underground excavation and between any two adjacent steel ribs placed less than 10 feet on center.

H. Limit spacing of blocking and wedging points on outside flange of steel set to 48 inches maximum, unless otherwise shown.

I. Steel lagging may be used in any amount in any underground excavation providing it permits ready placement of shotcrete and flow of concrete around it.

J. Place wedging, blocking, lagging and cribbing in an open arrangement to permit ready placement of shotcrete and flow of concrete through and around them.

K. Repair or replace structural steel supports placed improperly or damaged.

3.08 PERMANENT LINING:

A. Cast-In-Place Concrete:

1. Invert:
   a. Prior to installing drainage system and constructing invert slab, clean off loose material.
   b. Install drainage pipes and place porous subgrade material as shown and in accordance with Section 02625.
   c. Place impervious membrane over subgrade layer and extend it continuously up sides of invert and above top of expansion-joint material, taking care to prevent puncturing and tearing it. Tape laps and repair tears or punctures in membrane with material recommended by membrane manufacturer.
2. Permanent lining: In accordance with Sections 03100, 03200 and 03300 and as follows:
   a. Prior to placement of concrete, remove timber blocks or wedges extending into concrete design line by such means as to not endanger stability of surrounding ground.
   b. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure. Do not use pneumatic equipment with high-velocity delivery, unless it has velocity-discharge control and unless its discharge line is continuously embedded at least four feet in fresh concrete
   c. Fill spaces around posts, ribs and lagging beyond limits of concrete lining. Use concrete, grout or mortar as best suited to conditions at particular locations.
   d. Fill enlargements of tunnel excavation beyond dimensions shown with concrete or grouted prepacking.
   e. Force concrete into contact with lagging and ribs

f. After concrete has attained its design strength, perform contact grouting to fill voids in accordance with Section 02431.

g. For sections in which permanent lining includes steel ribs, comply with sequence of operations and details shown.

h. Starter walls:

1) Construction of starter walls, 18 inches minimum height, permitted as separate pour after supporting concrete has attained strength to support starter wall forms.

i. Tolerances for cast-in-place permanent tunnel lining are based on design alignment, not on actual alignment. Locate initial support with sufficient allowance for permanent lining without violating clearance requirements.

B. Precast-Concrete Tunnel Lining:

1. Install tunnel lining so as to prevent damage to lining and coating. Use taper rings on curves.
2. When installing segments ensure that edges are clean and free from materials that could interfere with proper bearing of segments.
3. Place invert segment over properly shaped bed of pea gravel providing full and even bearing.
4. Alternate erection of side segments to prevent shifting of invert segment.
5. Erect precast-concrete segments immediately behind tunneling-machine cutter head and inside tail shield of TBM.
6. Complete ring of precast-concrete segments, without dislodging or damaging gasket. Lubricate gasket of last segment of each ring prior to its installation.
7. Backpack solidly each completed ring of precast-concrete segments with pea gravel and grout. Place pea gravel so as to ensure complete filling of space between lining and excavated surface of tunnel. Do not install more than two completed rings without filling space between lining and excavated surface of tunnel. Proceed with backfill grouting from bottom holes to top holes of completed rings. Use bulkheads as necessary to complete filling of space behind segments. Grouting pressure: 20-psi minimum, 30-psi maximum.
8. Continuously hold last six completed rings from heading by sufficient force to prevent separation of rings. Gap between adjacent rings not to exceed 1/8 inch.
9. Perform necessary remedial work. Damaged precast-concrete segments may be removed, repaired and reinstalled if approved.
10. Fill grout holes with portland-cement grout after backfill grouting is completed for each ring.

C. Hydrostatic-Pressure Relief System. [*5]

1. Install hydrostatic-pressure relief system as shown.

3.09 INSTALLATION OF ELECTRICAL INSULATIVE COATING:

A. Apply coating prior to placement of invert and safety-walk concrete on precast segmented lining. Do not apply in tunnels where full circumference water proofing membrane is sown or specified.

B. Surface Preparation:

1. Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.

C. Application:

1. Apply in two coats of equal thickness totaling 20 mils minimum dry-film thickness (DFT) in accordance with recommendations of coating manufacturer.

3.10 TUNNEL CONNECTIONS AND TERMINATIONS AND TEMPORARY BULKHEADS:

A. Connect new tunnels to existing structures by removing existing bulkheads and constructing junction as shown.

B. By means of temporary bulkheads, seal terminations of tunnels which are not connected to existing structures.

C. Design temporary waterproof bulkheads where and when necessary, capable of resisting lateral pressures and capable of removal without damaging permanent lining. Obtain approval of design prior to construction.

3.11 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:

A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320 and 02260.

B. Seal such openings when no longer necessary.

C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has attained design strength, backfill remaining void in accordance with Section 02320.

3.12 DEFECTIVE LINING:

A. Precast concrete segmented tunnel lining will be considered defective unless it is watertight, properly finished and within specified tolerances and has undamaged edges and joints.

B. Watertightness Criteria: Section 03300.

3.13 CORRECTIVE WORK:

A. Repair of Concrete Segments: Repair segments which have minor chipping of edges and corners, using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new segments those cracked segments which the Engineer determines will impair structural integrity of tunnel lining.
   1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
   2. Mix and place epoxy mortar as recommended by manufacturer of epoxy resin. Grind rough or raised projections smooth and flush with adjacent surfaces.

3.14 LEAK REMEDIATION:

A. If water leakage into tunnel exceeds specified allowable limit, undertake remedial measures such as injection of epoxy, bentonite slurry, chemical grout, cement or a combination thereof in accordance with Sections 07125 and 07170.

B. Prior to beginning work, submit leak-remediation plan.

C. If possible, use existing grout holes for injecting material.

D. Establish injection pressure by means of on-site demonstration; do not exceed structural capacity of lining.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Add Article 1.1 B.13. for contracts where hydrostatic-pressure relief system work is directed to be performed.

***2**. For contracts where hydrostatic-pressure relief systems work is not directed to be performed.

***3**. Modification for contracts where hydrostatic-pressure relief systems work is directed to be performed.

***4**. Add 2.1 R. including 1.-4. for contracts where hydrostatic-pressure relief system work is directed to be performed.

***5**. Add 3.8 C. including 1. for contracts where hydrostatic-pressure relief system work is directed to be performed.

END OF SECTION

SECTION 02415

EARTH TUNNELING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the following:
   1. Earth tunneling for running sections, side drifts, adits and auxiliary tunnels.
   2. Installing tunnel linings.
   3. Concrete filled voids.
   4. The references in this section to steel ribs and lagging are restricted to the following:
      a. Misalignment correction.
      b. Stabilizing excessive deformations occurring in the precast segments.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Support of excavation: Section 02260.
   4. Underpinning, support and restoration of structures: Section 02255.
   5. Subway drainage system: Section 02625.
   6. Rock tunneling: Section 02410.
   7. Earth (EPBM) tunneling: Section 02416.
   8. Precast-concrete tunnel-lining: Section 02425.
   9. Concrete work: Sections 03100, 03200 and 03300.
   10. Membrane waterproofing: Section 07125.
   11. Bentonite waterproofing: Section 07170.
   12. Tunnel waterproofing (two-pass system): Section 07137.

C. Definitions:
   1. Earth tunneling: Mined excavation in earth. The following, among others, are classified as excavation in earth: Mixed-face, filled ground including rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel piles and sheeting and soft decomposed or disintegrated rock.
   2. Mixed-face tunneling: Mined excavation of earth and rock materials both in the same heading at the same time.
   3. Initial support: Elements designed, furnished and installed by the Contractor for stability and safety during construction preparatory to the construction of permanent lining.
   4. Permanent lining:
      a. For single-pass system precast concrete tunnel lining elements as shown.
      b. For the two-pass system there are two layers of linings, the initial and the final. The initial lining consists of precast concrete segments which are either jacked in place and retained by dutchmen and filled with concrete or grout to form the ring, or gasketed and bolted segments to form the ring. Final liner is a cast-in-place concrete liner.
         1) Concrete filled voids: Voids or chimneys which develop as the result of run-in of soil into the tunnel and which extend entirely or partially to the surface. These voids are then filled with lean concrete.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications.
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. Geotechnical Design Summary Report (GDSR) included as Appendix G to the General Requirements.
   3. AASHTO: M33, SDMS.
   4. MS: MIL-P-26915.
   5. FS: TT-S-230, TT-W-261.
   6. ASTM: A36, A325, A709, C109, C144, C150, D638, D1056, D1304, D2240.
   7. FGCC: Standards and Specifications for Geodetic Control Networks.
   8. OSHA: Standard 1926.800(k)(2) AND (3), CFR 1910720, CFR 1926.800.

B. Watertightness Criteria: Section 03300.
   1. Survey Control:
      a. Provide qualified survey personnel in accordance with the General Requirements pertaining to Layout of Work.
   2. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the tunnels and placing concrete lining. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points either as a brass disk or a 1/2-inch diameter by minimum three-inch long anchor bolt with nut and washer.
      a. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks, using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.
      b. Make tunnel horizontal transverses closed loops and adjusted by the least squares method. Make tunnel vertical traverses closed loops and adjusted by distributing the error of closure equally through the turning points. Provide the Engineer with traverse adjustment results within 24 hours.
      c. Advance and verify underground tunnel control after each 500 feet of tunnel lining placement.
      d. Install vertical control points maximum 300 feet on center throughout tunnel.
      e. Install inter-visible theodolite instrument platform mounting brackets in the shotcrete lining, at or below the springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations.
      f. See Part 2 - Products for bracket and surveyor platform specifications.
      g. Survey Data Collection:
         1) Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.
         2) Survey data collection files transmitted to the Engineer are to contain a time and date stamp for each observation, original field measurements, and the correctly computed coordinates/elevations in addition to the survey data tags necessary to recompute the file if required.
         3) Preserve original unedited data collection files and provide one copy of each file to the Engineer.

h. Survey Equipment Adjustment and Calibration:

1) Adjust instrument for collimation error every six months or whenever difference between direct and reverse readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument reading by amount of least count.

2) The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distance at an approved NGS baseline. Recalibrate an EDMI if physical damage is incurred.

3) Compute calibration results using procedures in NOS NGS-10 Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.

4) Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specified accuracy.

5) Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.

6) Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.

7) Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly or upon request. Number and tag each tribrach with date of last adjustment.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings:

a. Design, specifications, method of operation and other data pertaining to tunnel shields and tunnel machine.

b. Manufacturers' printed literature for the products, equipment and instrumentation proposed for use in the work, annotated clearly to indicate exact items to be used

2. Working Drawings:

1) Detailed description, data or calculations of proposed facilities, equipment to be utilized and method of construction, including but not limited to, the following: Method of operation and other data pertaining to tunnel shields and tunnel machine, hoisting plant, tunnel ventilation, lighting and drainage; ground water control methods; pre-support (chemical) grouting methods; temporary shafts, cuts, ramps and tunnels; breakouts; cross passages; bulkheads; initial support; method of construction including details of installation of initial support and permanent lining; method of controlling line and grade of shield and lining; details of rib and segment ring movement measurement; details of method and procedure for the expansion of initial lining including jack pressures

and test for completion of expansion; details of method and procedure for preventing the expansion jacks and dutchmen from dropping out from construction induced loads or vibrations; details of method procedure for filling expansion gaps with concrete and grout behind the initial tunnel support system.

b. Have drawings and computations certified by a professional engineer experienced in earth tunneling and registered in the jurisdiction in which the work is to be performed.

c. Details of temporary ventilation:
   1) In the event it is planned to use equipment not covered by Section 101, Article VII.A., Safety Requirements, submit details of such equipment.
   2) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.

d. Leak-remediation plan:
   1) Include proposed application method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
   2) Submit prior to beginning leak-remediation work.

e. Tunnel shield guidance system: Equipment and software details and operation. Include specific information concerning the method of controlling line and grade of Tunnel Boring Machine.

f. Contingency expansion or installation plans for initial lining: Submit in anticipation of the possibility that initial lining expansion or installation procedure is not successful.

g. Survey Control:
   1) Type and location of horizontal and vertical control monuments to be set.
   2) Survey procedures and equipment.
   3) Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to initial liner, brass mounting screw and standing platform underneath instrument mounting bracket.
   4) Survey data collection equipment and software; and traverse reduction and adjustment software.
   5) Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
   6) Tribrach adjustment method and equipment.

3. Certification: Certified test report from the independent testing agency verifying that properties of concrete or non-shrink cement grout are as specified.

4. Documentation:
   a. Permits for disposal of excavated material: Each permit and release from each property owner where excavated materials will be deposited absolving the Authority from responsibility in connection with the disposal of such materials.
   b. Air quality reports: Reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in working environment.
   c. Qualifications of the following:
      1) Survey personnel.
      2) Specialists in responsible charge of groundwater control.

3) Operators in responsible charge of operating the shield or the tunnel machine.
4) Specialists in responsible charge of pre-support (chemical) grouting program.
5) Independent testing agency.

5. Samples:
   a. Premolded circumferential filler: Two, each two feet square.
   b. Asphalt-saturated felt filler: Two, each two feet square.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Maintain an adequate supply of straight and tapered precast concrete segments for tunnel lining on site.

B. Avoid damage to surfaces and undue strain on segments during handling.

C. Chemical Grout: Transport, store and handle chemical grout, catalysts, inhibitors, additives and buffers in accordance with manufacturer's instructions.

1.05 JOB CONDITIONS:

A. Groundwater Control:
1. Control groundwater along the tunnel alignment and within the tunnel heading to prevent the following:
   a. Heaving of invert, boiling conditions, hazardous seepage and sudden inflow of soil at the tunnel face and at the tail of the tunnel shield.
   b. Loss of ground and surface subsidence.
2. Accomplish groundwater control by, but not limited to, the following:
   a. Lower the water table in accordance with Section 02240.
   b. Underpin and support structures in accordance with Section 02255.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Precast-Concrete Tunnel Lining Segments: Section 02425.

B. Reinforcing Steel: Section 03200.

C. Concrete: Section 03300.

D. Track Drainage: Section 02625.

E. Grout: Ingredients that are compatible, noncorrosive to steel and free from calcium chloride.
1. Cement: ASTM C150, Type I.
2. Sand: ASTM C144.
3. Water: Potable.
4. Admixtures and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding, and water-reducing agents; and bentonite may be used if approved.

F. Non-Shrink Cement Grout:

G. Chemical Grout: Gel-type as follows:

1. Self-supporting gel grout using a soluble polyacrylamide, producing no toxic hazard and which can be mixed in such proportions that dilute aqueous solutions, when properly catalyzed, will form stiff gels and yield true solutions at concentrations sufficiently high to accomplish soil solidification.
2. Polymer solution mixed using formulations and procedures to provide variable gel times in accordance with the manufacturer's recommendations.
3. Source: Chem G-9 by Polymer Chemicals, Incorporated or equal.

H. Ribs, Beams, Channels, Plates and Retainers: ASTM A36.

I. Timber for Blocking, Lagging, Foot Blocks and Cribbing: Sound, well-seasoned hardwood timber of rectangular cross section.

J. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectionable material, such as soft particles, coal and lignite particles or friable particles, graded from 1/4 to 3/8 inch in size.

K. Sand: Section 03300, fine aggregate, except with 100-percent passing U.S. Standard Size 16 sieve.

L. Sealant and Back-Up Rod:
1. Siloxane-polymer sealant: FS TT-S-230.
2. Back-up rod: 5/8-inch diameter polyethylene.

M. White Lead (for Coating Grout-Plug Threads): FS TT-W-261.

N. Bentonite Slurry: Stable suspension of powdered bentonite in water.

O. Epoxy Mortar: Two-component, epoxy-resin and sand system without solvents; containing 100-percent solids, workable from 50F to 60F.
1. Sand grading: Three parts No. 16 sand to one part No. 90 sieve sand, high-silica content, dry and bagged.
2. Mortar mix: One part epoxy to maximum of one part sand.

P. Premolded Circumferential Filler:
1. Closed-cell neoprene, ASTM D1056, Grade SCE-45.
2. Water absorption: No increase in weight in excess of two percent when tested in accordance with ASTM D1056 and completely immersed in water for 70 hours at 65F to 95F.
3. Hardness: 50 plus-or-minus five on the Shore A durometer as measured by procedures given in ASTM D2240.
4. Size: One-inch thick, width and length as shown.

Q. Asphalt-Saturated Felt Filler: AASHTO M33.

R. Electrical Insulative Coating:
1. Properties: Moisture-insensitive coating, 100-percent solids, containing no solvents, for use on dry or damp concrete or steel surfaces, with the following additional requirements:
   a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days.
   b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
   c. Dielectric constant: ASTM D1304 as follows:
      1) 60 Hertz: 3.4-3.5.
      2) 1,000 Hertz: 3.3-3.4.

d. Power factor: ASTM D1304 as follows:
   1) 60 Hertz: 0.006-0.007.
   2) 1,000 Hertz: 0.03-0.04.
e. Viscosity: 6,000 centipoises plus-or-minus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.

2. Primer: Zinc-rich, MS MIL-P-26915 (USAF) Type 1, Class B.

2.02 GROUT MIX DESIGN:

A. Stage I Mix: To develop compressive strength of 100 to 120 psi at 24 hours.
1. Mix sand and cement dry.
2. Add minimum water to achieve water-cement ratio compatible with pumping and placing requirements.
3. Mix in high-speed mixer for minimum of three minutes.
4. Prepare batches so that standing time does not exceed 45 minutes.
5. Prepare trial mixes for laboratory testing.
6. Perform tests of compressive strength in accordance with ASTM C109.

B. Stage II Mix: Neat cement and water.

2.03 INSTRUMENT PLATFORM MOUNTING BRACKETS:

A. Construction: Steel, minimum 1/8-inch thick, having a smooth finish where instrument attaches. Make bracket rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent, add bracing supports as directed by the Engineer.

B. Bracket Supports: Attach bracket supports to the underside of platform mounting bracket to provide a clear and unobstructed working area at and above platform.

C. Size: Sufficient length and width to allow efficient set-up and operation of various theodolite and electronic distance measuring instruments (EDMI).
1. Minimum width: Nine inches.
2. Minimum length: Sufficient to allow a mounted instrument a at least one foot clearance from tunnel lining.

D. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.

E. Forced Centering Hole: Provide each platform mounting bracket with a forced centering hole to accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach.
1. Provide a brass mounting screw that is hollowed and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir optical plummet.
2. Mill force centering hole and brass mounting screw to match each other within 0.001 inch tolerance.
3. Provide the Engineer with three mounting screws for duration of the Contract.

F. Surveyor Platform: Provide a platform underneath each instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from wither side of instrument.

PART 3 - EXECUTION

3.01 TEMPORARY VENTILATION:

A. Provide, operate and maintain for duration of project a temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities, and is capable of providing twice the required volume and velocity of air flow as specified in OSHA Standard 1926.800(k)(2) AND (3). Assume that other conditions likely to produce harmful vapors or gases may be present at portions of the alignment. Remove system from site when work is completed.

B. Use equipment which is adequate to maintain sufficient supply of fresh air in underground work areas.

3.02 SAFETY REQUIREMENTS:

A. Perform work so as to maximize safety and reduce exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

B. Emergencies:
   1. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.
   2. For emergency purposes, have always on-site and ready for use a minimum of 12 steel rib rings and lagging sufficient to support 25 feet of tunnel.

C. Perform tunnel construction so as to minimize ground movement in front of and surrounding tunnel and prevent subsidence of surface, structures and utilities above and in vicinity of tunnel.

D. Support ground continuously so as to prevent loss of ground and keep perimeters and maintain stability of tunnel faces, passages and bottoms of shafts.

E. If the Environmental Property Assessment Reports required in Section 101, indicate the potential for encountering contaminated groundwater or contaminated soil along the alignment, have electrical equipment in the tunnel and shafts comply with OSHA regulations CFR 1910720 and CFR 1926.800. Provide toxic and explosive gas sensors in the shafts, running tunnels and on the shield at the tunnel face to monitor the presence of potentially toxic or combustible materials.

3.03 BLASTING:

A. Whenever material requiring blasting is encountered, perform the work in accordance with Section 02410 and Section 101.

3.04 DISTANCE BETWEEN HEADINGS:

A. Maintain longitudinal distance of no less than 150 feet between adjacent tunnel headings being simultaneously excavated.

B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that initial support in first tunnel is completely installed and that voids behind lining are filled and tendency of lining to distort is minimized before commencing work on second tunnel.

C. Where two adjacent tunnels are to be installed at different levels, complete and support lower level tunnel first as specified for previously excavated adjacent tunnel.

3.05 SURVEILLANCE OF HEADINGS:

A. If tunnel invert is below groundwater level, maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.

B. Use of monitoring devices, such as closed-circuit television, which permit continuous monitoring of conditions at face by qualified observers from outside tunnel is permitted subject to approval.

3.06 AIR QUALITY:

A. Conduct drilling and tunneling operations by methods and with equipment which ensure control of dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.

B. Provide instrumentation for testing quality of tunnel atmosphere and obtain samples under working conditions at prescribed intervals. Submit results of quality tests.

3.07 DISPOSAL OF EXCAVATED MATERIAL:

A. Dispose of excavated materials at locations outside the Authority's right-of-way.

3.08 DETECTION OF MOVEMENT:

A. Rib and Segment Ring Movement:
   1. Monitor dimensions and elevations of ribs and segmental rings as follows:
      a. Measure width of each rib and segmented ring at spring line to within plus-or-minus 0.01 foot.
      b. Measure height of each rib and segmented ring from crown to invert or foot block to within plus-or-minus 0.01 foot.
      c. Measure crown elevation of each rib and segmented ring and elevation of each footblock to within plus-or-minus 0.01 foot.
   2. Take measurements of width and height of each rib and crown elevation of each rib and each segmented ring within one hour after each rib or segmented ring is expanded or emerges from tail of machine.
   3. Take measurement of width and crown elevation of each segmented ring within 12 hours after each segmented ring is expanded or emerges from tail of machine.
   4. Following such initial readings, the Engineer will select one segmented ring in each 12-foot section of tunnel for additional measurements. Take measurements of width, height and crown elevation of each segmented ring on selected sets of ribs or rings three days after selected ring erected, and at monthly intervals thereafter until they are concreted in.
   5. If impracticable to obtain these measurements because of design of tunneling equipment or method of construction, use alternative methods of measurement as approved.
   6. If measurements indicate excessive deformations are occurring, take corrective measures, such as installation of ribs, and additional measurements on selected elements and on additional elements as directed.

B. Ground Movement: Install, maintain and make observations of instrumentation shown..

3.09 CONCRETE FILLED VOID:

A. Should run-in of the soil produce a concrete filled void as defined above, stop tunneling operations immediately and notify the Engineer. Secure the tunnel and construct a temporary bulkhead to prevent further run-ins. Provide a bulkhead which is capable of resisting lateral earth and hydrostatic pressure, waterproof and capable of removal without damage to the tunnel liner.

B. Fill the void from the surface with lean concrete.

C. Resume tunneling operations after a minimum of 48 hours has passed after filling the voids with lean concrete and after approval of the Engineer.

3.10 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
1. Cast-in-place tunnel concrete: Place cast-in-place tunnel concrete to the following tolerances:
   a. Tunnel lining:
      1) Departure of tunnel from line or grade shown as measured from working point of tunnel: One inch.
      2) Variation in thickness of lining at any point: Minus zero inch.
      3) Variation in internal diameter at any point: Plus-or-minus one inch.
      4) For two-pass system where final cast-in-place liner is less than 12 inches but equal to or greater than nine inches, provide additional reinforcing as shown on the Contingency Reinforcement Drawing, at no additional cost to the Authority.
      5) No final liner wall thickness less than nine inches will be accepted. Tunnel remining necessary to maintain the allowable final liner thickness is at no additional cost to the Authority.
   b. Invert: Section 03300.
   c. Safety walk: Section 03300.
2. Precast concrete segmented tunnel lining: Install precast concrete segmented tunnel lining to tolerances shown.

3.11 EQUIPMENT:

A. General: Use shields and machines which can be controlled to desired line and grade and minimize over excavation and loss of ground and provide for erection of specified tunnel linings.

B. Tunnel Shields:
1. Use tunnel shields suitable for work conforming to shape of tunnel and having uniform exterior surface from leading edge of head or poling plates to rear edge of tail and free of projections. Horseshoe-shaped shield may have closed or open bottom; circular shield to have closed bottom. Permanent poling plats incorporated in the hood of the shield are prohibited.
2. On shield, provide substantially proportioned hood, which projects not less than two feet, nor more than two feet six inches, beyond shield bottom and rear overhang or tail long enough to provide at least 12 inches of overlap beyond last installed element of lining when shield has been pushed forward to fullest extent possible. Ensure that

annular space between tail and lining is in accordance with current practice but in no case greater than 1-1/2 inches.

3. Provide a shield with either a suitably designed hydraulically operated breasting system with tight breast boards, with breast-jacks or breast-tables or both, and such other means necessary to accomplish the same results. Hinged or "orange peel plates" as the sole means of face support will not be approved. In addition, provide such means as necessary to continuously support the face of the tunnel without loss of ground through a continuous grouting operation where necessary.
4. Make the pattern of breast-jacks and soldier beams to fully support the upper 50 percent of the tunnel face in order to provide direct face support. Provide the forward bulkhead with reaction points for trench jacks to support the upper half moon breast boards.
5. Mechanical excavators may be used provided that they can be retracted and do not interfere with the capability of breasting. Do not allow excavation to extend beyond the leading edge of the hood.
6. Design breasting system to do the following:
    a. Permit drilling and soil sampling from the exploratory holes for grouting from the face of the shield.
    b. Provide space and facilities for grouting for ground stabilization.
    c. Provide capability to install probes ahead of the excavation face.
7. Include propulsion system on shield capable of moving shield in forward direction, while maintaining construction tolerances with respect to line, grade and direction. Design propulsion system so that in event of failure of propulsion-system elements there is no over stressing and distortion of lining, and there is no movement backward.
8. Jack loads: For precast-concrete tunnel lining, use shields and machines in which each jack load is applied uniformly at centerline of longitudinal rib of segment and over area equivalent to cross section of longitudinal rib. Use a minimum of 18 jacks each of 150-ton capacity, or 24 jacks each of 125-ton capacity, located at centerline of each longitudinal rib of lining.
9. Incorporate seal in tail of each shield to prevent leakage of grout into tunnel space between shield and lining.
10. Erection system: Equip shield with erector arm or erection system capable of handling largest sizes of lining and of erecting sections of lining to tolerances shown without damage to lining.
    a. Use erection system that allows for prompt expansion of the segment against the soil when segment emerges from tail of the shield.
    b. Use erection system that is fully integrated with the tunnel machine and capable of erecting the pre-cast liners in a smooth operation.
    c. Have previously installed segments in a ring supported prior to installation of ring expansion jacks.
    d. Have the erector arm equipped with a hydraulic system which prevents sudden movement of the liner during erection and which provides a fail-safe system should hydraulic pressure be lost in order to prevent accidental segment droppage.
11. Provide an adequate expansion system to include the following:
    a. Capability to start expansion as soon as clearances permit.
    b. Reaction for expansion jacks independent of shield and shield movement.
    c. Expansion system expanding outward and upward.
    d. A minimum capacity expansion of two 100-ton hydraulic jacks.
    e. If required because of insufficient expansion, ability to modify the system by increasing the jack capacity, adding more jacks and points of expansion, or by other means in accordance with a plan subject to the Engineer's approval.

12. Tunnel guidance: Provide a tunnel shield guidance system for automatic computation of curved axis coordinates to maintain proper tunnel line and grade within specified tolerances.
    a. Use guidance system capable of calculating and displaying the position and attitude of the tunnel shield or boring machine (TBM) relative to the designed tunnel axis at each point, including predicted points at the face of the shield or some specified distance ahead of the shield.
    b. Include in the tunnel shield guidance the following features:
        1) The parts and equipment necessary to continually and automatically measure horizontal, vertical, and axial displacement as well as horizontal, vertical, and main axis rotation.
        2) A control unit capable of storing the design tunnel alignment using a three-dimensional coordinate system and displaying the present position and attitude of the shield or the TBM and its predicted deviation from the design axis of the tunnel.
        3) Motorized electronic theodolite with electronic distance measuring instrument (EDMI) and laser. Have the laser directed through the eyepiece of the theodolite, used to automatically update laser beam directional information. Use the EDMI to automatically update the shield or TBM drive distance.
        4) An above-ground computer which enables entry, modification and verification of the designed tunnel axis coordinates.
            a) Have the above-ground computer display, print and digitally store the information available at the control unit and to document the position and progress of the tunnel drive without leaving the office. Make this information available to the Engineer upon request or at the end of each shift.
            b) Have the above-ground computer electronically connected to the equipment underground via cable or modem.
    c. Source for guidance system: Subject to the requirements, use ZED-260 or equal.
13. Equip shield with permissible electrical systems equipped with toxic gas and combustible gas sensors. Have toxic gas and combustible gas sensors linked to the machine operation to automatically shut the machine down should measured gaseous concentrations exceed established safety threshold values.

C. Tunnel Machines: Use tunnel machines which minimize loss of ground ahead of and around machine and provide for erection of specified tunnel linings within machine. Use machines which have same features as shields except for face-support requirement. For tunneling with Earth Pressure Balance Machines (EPBM) see Section 02416.

D. Grouting Equipment:
1. For pumping grout, use pump capable of developing specified uniform pressure at grout hole connection and hoses with minimum inside diameter of 1-1/2 inches. Provide automatic recording of volumes and pressures during grouting operations.
2. Provide mixing equipment with capacity to fill voids outside last ring after each advancement of tunnel shield.
3. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified
4. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.
5. Use equipment that allows flushing with grout-intake valve closed, water-supply valve open and grout pump running at full speed.

6. Provide two pressure gauges, one at the pump and other on manifold hookup at collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of grouting program.
7. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
8. Provide grouting equipment with means of accurately determining amount of grout injected.
9. Furnish accurately calibrated, high-precision pressure gauge to periodically check accuracy of pressure gauges.

3.12 OPERATIONS BY TUNNEL SHIELDS AND MACHINES:

A. On initial setup, properly support tunnel shields or tunneling machines on concrete cradle at lines and grades which permit correct installation of tunnel lining. Based on design or existing soil conditions or both, pre-support grouting or dewatering or both may be required.

B. During forward movement of shield, provide sufficient support at excavation face to prevent movement of materials, except such materials as are physically displaced by elements of shield itself.

C. Control face efficiently using appropriate support procedures and methods, such as breasting, poling, face jacks, slide tables, singly or in combination.
1. No tunnel advance will be permitted until the crown has been grouted, and it has been determined by the Engineer that additional pre-support grouting is not required, to provide a stable soil mass into which to tunnel.
2. Perform pre-support grouting from existing ground surface locations shown. Extend the grouted arch at least two tunnel diameters in front of the shield when grouting from the surface and one tunnel diameter in front of the shield when grouting from within the tunnel prior to an advance of the tunnel face. The minimum required thickness of the grouted arch is five feet.
3. Additional pre-support (chemical) grouting will be required if, in the judgement of the Engineer, the ground conditions in advance of the excavation require it.
4. During probing, identify substantially cohesive deposits (such as TI, P1/P3 soils – See Appendix G, Geotechnical Design Report, of the General Requirements) which are continuous and occupy essentially the upper 50 percent of the face. Additionally, the observed performance of the excavation with respect to surface settlement and lateral deformation determined from the geotechnical instrumentation monitoring program will be evaluated in conjunction with the probe data.
5. More extensive pre-support ground control other than grouting may be required depending on the effectiveness of the dewatering system, the pre-support grouting and the data obtained from the geotechnical instrumentation program.

D. Dispose of excavated materials as required.

E. During shutdown periods, support face of excavation by positive means such as breasting of face. Do not rely solely on support by hydraulic pressure. Provide surveillance as specified above.

3.13 INSTALLATION OF TUNNEL LININGS:

A. Lining of One-Pass System or Bolted Initial Liner of Two-Pass System:
1. Install tunnel lining so as not to damage lining or coating. Use taper rings on curves. Develop and submit the details of taper rings not shown.

2. When installing segments, ensure that edges are clean and free from material that could interfere with proper bearing.
3. Install bolted connections consisting of one bolt, one nut, two grommets and two washers arranged and conforming to sizes as shown. Tighten bolts in accordance with AISC requirements for structural joints. After each advance of shield or tunneling machine, check tension of bolts on last two rings and retighten or replace if necessary those bolts which do not meet requirements.
4. Replace grommets at bolts which show signs of leakage.
5. Staggering Longitudinal Joints:
   a. For metallic lining, stagger longitudinal joints in adjacent rings by one half of segment length, but in no case by less than 25 percent of segment length.
   b. For precast concrete segmented lining, stagger joints in adjacent rings by one third of segment length. One joint between adjacent rings may be continuous.
6. After approval of bolted connections, clean out caulking recesses.
7. Insert metallic lead caulking in metallic lining or sealant with backup rod in precast-concrete lining so that it completely fills recess and forms tight and continuous plug providing watertight joint.
8. Recaulk joints which are leaking.
9. After each advance of shield or tunneling machine, fill voids between lining and excavated surfaces with grout. Where approved, pea gravel followed by neat portland-cement grout or one-to-one sand-cement grout may be used to fill voids in lieu of two-stage grouting. For special purposes, finer sand may be used. Do not exceed 30 psi at grout hole.
10. Perform grouting in two stages as follows:
    a. First stage: Perform immediately after each forward thrust of equipment, at nozzle pressure which will not cause movement of soil or lining nor damage to lining, but not exceeding pressure specified. Keep topmost hole in liner open as air vent. Assist Engineer in checking adequacy of first stage grouting.
    b. Prior to performing Stage II grouting, completely drill out previously filled grout holes and prepare for regrouting. When grouting of ring is completed and grout has set, clean threads of holes and plugs, coat plug threads with white lead, and screw plugs completely and tightly into holes.
    c. Second stage: Fill soft spots or voids which may be detected, no later than 24 hours nor more than 50 feet behind first stage grouting. Use nozzle pressures specified.
11. Avoid spillage or leakage of grout into tunnel. Clean up spillage promptly and remove it from tunnel.
12. Complete electrical bonding of segments as shown.
13. Install corrosion test rods through grout holes where shown, ensuring full contact with surrounding earth. Use insulating bushing in grout holes.
14. Support trailing edge of last installed ring by means of horizontal tie rod or vertical strut inserted before shield or tunneling machine is advanced. Keep support in place until grouting around lining has been completed and the tendency of lining to distort or surrounding ground to move has been overcome.
15. Repair or replace as directed damaged segments in previously placed ring.
16. Completely seal area of tunnel roof described by arch of approximately 45 degrees each side of tunnel's vertical centerline to at least one-foot beyond outside face of contact rail and on opposite side of track to one-foot beyond outside face of running rail. Perform such work in accordance with manufacturer's recommendations.

B. Expanded (Jacked) Initial Liner of the Two-Pass System:
1. Install tunnel lining so as not to cause damage to lining or coating. Use taper rings on curves as necessary. Develop and submit the details of taper ring not shown.

2. When installing segments, ensure that edges are clean and free from material that could interfere with proper bearing.
3. Ensure that reach ring is positioned properly and that each segment is supported in a secure position during erection within the shield, shoving of the shield expansion of the ring. Expand the rings with the use of jacking rings (or other approved equivalent measures). However, to provide proper bearing at the joints of the segments, use two 100-ton capacity hydraulic jacks in the circumferential "gap" in the segmented precast concrete ring and maintain pressure in these jacks. Install a plywood board on the outside of the initial liner at the "gap" to prevent ground loss during further expansion and installation of the liner ring.
4. Immediately after leaving the shield, expand initial liner segments outwards and radially using hydraulic jacks with jacking rings (or other approved equivalent measures) and hydraulic jacks in the "gap" so that the segments are in good contact with the ground. After the initial liner segments are fully expanded, install the steel dutchmen in the "gap" of the segmented ring and ensure proper bearing with the use of shims if necessary, and secure these dutchmen to prevent movement or loss of support.
5. First Stage Contact Grout (cement-sand grout):
    a. Perform the First Stage Contact Grout on the outside of the initial tunnel liner to fill the annular space between the initial liner and the excavated surface within 16 hours after initial tunnel support ring installation, but not more than the installation of four rings, or when directed by the Engineer. Use nozzle pressure that will not cause movement of soil or lining nor damage to the lining, and not exceeding 30 psi at the grout hole.
    b. Subject to the Engineer's approval, perform the First Stage Contact Grout on the outside of the initial tunnel liner to fill the annular space between the initial liner and the excavated surface after each advance of the tunnel machine. Use nozzle pressure that will not cause movement of soil or lining nor damage to the lining, and not exceeding 30 psi at the grout hole.
6. After the installation of the dutchmen in the "gap" and the removal of the jacks from the "gap", dry pack the "gap" with non-shrink grout after the heading has advanced no further than 150 feet past the ring, or within 48 hours from the time of the initial ring expansion.
7. After expansion and initial deformation of initial liner ring has occurred, if measurements indicate excessive deformations or indicate additional "squat" of more than one inch at the crown, install internal bracing to arrest additional deformation. Place contact grout behind the initial precast liner.
8. Seal leaking joints.
9. Avoid spillage or leakage of grout into tunnel. Clean up spillage promptly and remove from tunnel.
10. Support last installed ring by means of an erection arm, expansion system, horizontal tie rod or vertical strut inserted before shield or tunneling machine is advanced. Keep support in place until the tendency of lining to distort, or surrounding ground to move, has been overcome.
11. Repair or replace as directed damaged segments in previously installed rings

3.14 INSTALLATION OF ELECTRICAL INSULATIVE COATING:

A. Apply coating prior to placement of invert and safety-walk concrete on precast segmented lining.

B. Surface Preparation: Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.

C. Application: Apply in two coats of equal thickness totaling 20 mils minimum dry-film thickness in accordance with recommendations of coating manufacturer.

3.15 CONCRETE CONSTRUCTION:

A. Prior to construction of the permanent liner, install the tunnel waterproofing with water barriers as shown. See Section 07137.

B. Complete electrical bonding of lining and invert shown. Electrically bond the invert of the final lining at each end of each unit.

C. Install corrosion test rods where shown, ensuring full contact with surrounding earth. Use bushing in grout holes.

D. Perform cast-in-place concrete work in accordance with Sections 03100, 03200 and 03300.

E. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.

F. Prior to placement of concrete, remove timber blocks or wedges extending within concrete design line so as to avoid compromising stability of initial support and surrounding ground.

G. Fill enlargements of tunnel excavation beyond dimensions shown with concrete or grouted prepacking as approved.

H. Schedule erection of concrete tunnel lining so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.

I. Perform contact grouting through grout nipples, in such quantity and at sufficient pressure to fill voids. Use grouting pressure shown.

3.16 TUNNEL CONNECTIONS AND TERMINATIONS AND TEMPORARY BULKHEADS:

A. Connect new tunnels to existing structures by removing existing bulkheads if necessary and sealing junction as shown.

B. Provide temporary bulkheads to seal terminations of tunnels which are not connected to permanent structures.

C. Design temporary bulkheads where and when necessary. Obtain approval of design prior to construction. Provide bulkhead which is capable of resisting lateral earth and hydrostatic pressures, waterproof and capable of removal without damage to permanent liner.

D. Provide portal transitions as shown.

3.17 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:

A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320, 02240 and 02260.

B. Seal such openings when no longer necessary.

C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

3.18 DEFECTIVE LINING:

A. Precast concrete segmented bolted tunnel lining will be considered defective unless it is watertight, properly finished, within specified tolerances and has undamaged edges and joints.

B. Watertightness Criteria: Section 03300.

C. Precast concrete expanded or jacked tunnel initial liner is considered defective unless it is properly finished, within specified tolerances and has undamaged edges and joints.

D. Defective concrete criteria for cast-in-place final liner for the two-pass system: Section 03300.

3.19 CORRECTIVE WORK:

A. Repair of Precast Concrete Segments: Repair segments which have minor chipping of edges and corners, using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new segments those cracked segments which impair structural integrity of tunnel lining as determined by the Engineer.
   1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
   2. Mix and place epoxy mortar as recommended by manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.

B. Contingency Reinforcement: When tunneling misalignment results in a final liner thickness of less than 12 inches but greater than or equal to nine inches, install contingency reinforcement as shown. Furnish and install contingency reinforcement when required at no additional cost to the Authority.

C. Correction of Misalignment: In the case of misalignment which will result in a final thickness of less than nine inches, enlarge the tunnel excavation by remining or as otherwise approved. Provide additional materials and redesign required due to misalignment at no additional cost to the Authority.

3.20 LEAK REMEDIATION:

A. If water leakage into tunnel exceeds specified allowable limit, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout or combination thereof in accordance with Section 07125 and 07170.

B. Prior to beginning work, submit leak-remediation plan.

C. If possible, use existing grout holes for injecting material.

D. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of lining.

END OF SECTION

SECTION 02420

ROCK REINFORCEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing and testing rock bolts, accessories, welded-wire fabric and miscellaneous steel for reinforcement of roc

B. Related Work Specified Elsewhere:
1. Rock tunneling: Section 02410.
2. Drilling and pressure grouting: Section 02431.

C. Definitions:
1. Initial support: Section 02410.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A185, A615, C144, C150, C579, F432.

B. Demonstration:
1. Prior to installation of rock bolts, arrange demonstration to show that specified test requirements have been met.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Prior to beginning work, submit the following:
      1) Locations, installation procedures and layouts of rock bolt installations.
      2) Pattern covering crown, sidewalls and face.
      3) Spacing, type, size and length of rock bolts, together with type of bolt accessories and surface covering.
      4) Relationship to rock discontinuities and execution sequence as well as time and distance from face for installation.
2. Samples:
   a. Bolts:
      1) At least 30 days prior to purchase of rock bolts, obtain samples of various sizes and types to be used from normal stock of manufacturer. Submit three such sample bolts of each type for testing by an independent testing agency designated by the Engineer.
      2) In the event of failure, provide additional samples until it can be demonstrated that bolts scheduled for delivery meet specified requirements.
   b. Grout additive:
      1) One two-ounce sample of pure, unpolished metallic aluminum powder or similar additive proposed for use in grout mixture.

c. Resin cartridges:
1) Three samples of each type of resin cartridge.

3. Certification:
a. Prior to installation of rock bolts, arrange demonstration to show that specified test requirements have been met.
b. Certificates verifying that samples for testing are from normal stock.
c. Certified mill reports of the bolts.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Rock Bolts and Accessories:
1. General requirements:
a. In accordance with ASTM F432.
b. Rock-bolt assembly: Bolt, bearing plate, washer and nut as specified.
c. At least 5-1/2 inches of rolled thread on outer end.
d. Fabricated from deformed bars.
2. Type 1, with resin end anchors and fully resin-encapsulated:
a. ASTM A615, Grade 60.
b. Approved method of resin anchorage to take specified tension.
3. Type 2, with mechanical end anchors and fully grouted:
a. ASTM F432, Grade 55, hollow core.
b. Approved expansion-shell anchorage on inner end.
4. Protective grease: Type used for bilge protection, containing rust-inhibiting compounds, factory-applied to threads of rock bolts and entire surface of nuts and washers.
5. Steel bearing plates: Square, not less than 3/8-inch thick, having bearing area of at least 36 square inches unless otherwise shown, with holes for injection of grout, for effective air release and for bolt. Hole in steel bearing plate of sufficient size to eliminate binding of bolt.
6. Nuts: Hexagonal head
7. Steel washers: Quenched and tempered. Hard-steel washers to be two inches in diameter and 1/8-inch thick unless otherwise shown. Center hole to be 1/8-inch larger in diameter than bolt with which it is to be used.

B. Miscellaneous Steel: Products of recognized manufacturer, comprising rock-bolt mats, mine roof ties, mine roof channels or similar members which are attached to roof surface by means of rock bolts.

C. Wire Fabric: ASTM A185, hot-dip galvanized.

D. Expansion Shells: As approved, capable of developing guaranteed minimum yield strength of rock bolt.

E. Grout and Mortar:
1. Cement: ASTM C150, Type I.
2. Water: Section 03300.
3. Additive: Pure, unpolished metallic aluminum powder or other approved additive.
4. Sand: ASTM C144, except maximum particle size limited to Size 8 sieve.

F. Lubricant for Threads and Washers: Molybdenum-disulfide base, Molykote G, Alpha Molykote Corporation or equal.

G. Resin Cartridges:

1. Two components as follows:
   a. Resin: High-strength unsaturated polyester with predominance of nonreactive inorganic filler.
   b. Catalyst: Containing peroxide with nonreactive inorganic filler.
2. Strength of mixed and cured resin when tested in accordance with ASTM C579:
   a. Compressive strength: 17,000 psi.
   b. Tensile strength: 7,500 psi.
   c. Shear strength: 4,800 psi.
3. Gel time:
   a. Gel and cure time of fast-set resin: Sufficient to permit bolt tensioning within 10 minutes or as recommended by manufacturer for the particular application.
   b. Gel time of slow-set resin: 15 to 30 minutes.
4. Materials to have thixotropic and viscous properties to permit adequate mixing of materials by manipulating bolt and to prevent mixture from running out of hole after mixing.
5. Shelf life: Six months, minimum.
6. Casing constructed of saturated polyester providing optimum resistance to moisture but easily fractured to enable complete mixing during installation.

2.02 MIXES:

A. Grout:
   1. Mix cement and sand dry.
   2. Add water to obtain water-cement ratio of approximately 0.4 by weight.
   3. Mix in high-speed mixer for three minutes minimum.
   4. Prepare batches so that time before use does not exceed 45 minutes.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL:

A. For underground excavation in rock on which bolts are used, install rock bolts within three feet of heading and within eight hours after blasting and prior to next shot.

B. When excavating with tunneling machine which provides direct ground support over machine such as a shield, install rock bolts within three feet of trailing edge of such support.

C. After each exposure of final rock surface, examine surface and confirm that rock bolt pattern to be installed will be adequate. Provide rock reinforcement that is adequate at all times to ensure safety of personnel and construction operations.

D. Drill holes in rock of depth and diameter necessary to accommodate bolt and to give anchorage consistent with type and length shown on Contract Drawings and approved shop drawings. Clean holes of drill cuttings, sludge and debris.

E. Avoid damaging threads on projecting end of bolt during installation.

F. Remove protective grease from threads and nuts.

G. Apply lubricant to threads. Use lubricant between washers and nuts.

H. Between bearing plate and steel washer, set bearing surface of nut perpendicular to bolt by use of bevel washers as necessary.

3.02 INSTALLATION OF RESIN-ANCHORED (TYPE 1) ROCK BOLTS:

A. For installation of resin-anchored rock bolts, have qualified representative of manufacturer supervise installation of initial 50 rock bolts. Have representative periodically reinspect installation procedures.

B. After drilling of rock bolt holes has been completed, insert resin cartridges in accordance with manufacturer's recommendations for anchorage conditions. Avoid rupture of cartridge skin.

C. To rupture cartridge and mix resin, insert bolt in hole rotating it at penetration rate of two inches per second through cartridge. Rotate bolt by mechanical means for five to ten seconds after bolt reaches bottom of hole or for 20 seconds minimum, whichever is least.

D. Apply tension as specified after recommended cure time for fast-set resin has elapsed, but before gel time for slow-set resin has elapsed.

3.03 INSTALLATION OF MECHANICALLY ANCHORED (TYPE 2) ROCK BOLTS:

A. Insert bolt in hole and set anchorage at necessary depth.

B. Tension bolt as specified.

C. Grout bolt as specified.

3.04 GROUTING OF ROCK BOLTS:

A. Pack or seal holes in bearing plate and between bearing plate and rock or shotcrete surface so that grout will be retained in hole.

B. Inject grout into hole at pressure not greater than that necessary to fill hole adequately.

C. Continue injecting grout until there is full return of grout through air vent.

D. If, during grouting of bolt, grout is found to flow from points in adjacent rock surface, plug or caulk leaks until leakage is stopped.

E. Grout only rock bolts located further than 50 feet behind working face as heading advances.

3.05 TENSIONING OF ROCK BOLTS:

A. Type 1 - Resin Anchored: Nominal tension to ensure proper nut tightening, not to exceed 20 percent of bolt guaranteed minimum yield strength.

B. Type 2 - Mechanically Anchored: Tension rock bolts by direct pull using approved hydraulic jacks and accurate calibrating techniques to between 60 and 80 percent of bolt guaranteed minimum yield strength; tighten nut.

C. If specified tension is not achieved for tensioned rock bolts, submit modified procedure for approval.

3.06 PULL TESTS ON INSTALLED BOLTS:

A. Equipment:
   1. Provide equipment consisting of suitably sized hollow ram jack, adjustable bearing truss for aligning direction of pull with centerline of bolt, extension bar for attaching

jack to bolt, hydraulic pump with gauge calibrated to read directly in pounds for ram being used, dial gauge which reads in increments of 0.001-inch over a range of two inches, magnetic or independent dial gauge mounting and other necessary accessories.

2. Calibrate pump gauge while connected to jack by testing machine before performing pull tests and at subsequent times as directed during construction period.
3. Maintain ready access to spare parts for testing equipment, especially gauges and pump seals, so that work will not be delayed.
4. Maintain pull test equipment in good working condition.
5. Ensure that equipment is used exclusively for pull tests. Store as directed.

B. Testing:

1. Conduct pull tests on installed rock bolts as directed.
2. Perform testing to:
   a. Measure head movement.
   b. Verify that specified tension can be sustained by bolt and anchorage without yield of steel or rock or slip of anchor.
   c. Check grouting procedure and prove grout strength.
3. Test rock bolts as follows:
   a. As selected at random by the Engineer according to the following schedule:

For Each Rock Bolt Type Installed	Required Testing
First 100 bolts	10
Remaining bolts	1 per 100

   b. No earlier than 24 hours and no later than three days after installation.
   c. To at least 80 percent of minimum specified yield strength.
4. Correction of defective work:
   a. For test purposes, bolt will be considered to have failed if outward movement of bolt anchorage in excess of 0.001-inch occurs and continues to occur at sustained loading below tension specified.
   b. Replace bolts that fail or pull out with bolts that meet specified testing requirements.
   c. Perform further testing, up to a minimum of five rock bolts in vicinity of failed bolt as directed. Replace as directed bolts that fail or pull out.

3.07 ROCK SURFACE REINFORCEMENT:

A. Install where shown, where directed and where approved when conditions at the site dictate, rock surface reinforcement consisting of wire fabric, miscellaneous steel or a combination of both. Rock conditions which may require surface reinforcement include, but are not limited to, places where the rock is weathered, excessively jointed or fractured or where it has a tendency to spall.

B. For installation of surface reinforcement and rock bolts simultaneously, place reinforcing materials over rock bolts between rock surface and steel bearing plate; tension bolt to draw reinforcing materials up tightly to the rock surface. Where wire fabric is used, overlap 1-1/2 times mesh dimension.

C. Where surface covering or reinforcement is placed after installation of rock bolts, attach materials to previously installed bolts by use of additional steel plate and nut by welding or

by supporting with additional rock bolts. Check existing rock bolts to which extra steel plate and nut are added.

D. Replace installed bolts which become loose after attachment of surface reinforcement.

E. Firmly attach surface covering or reinforcement so that it closely follows approximate contour of rock.

END OF SECTION

SECTION 02431

DRILLING AND PRESSURE GROUTING FOR ROCK TUNNELS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies drilling feeler, exploratory, drainage and other holes, furnishing and injecting grout and patching finished grout holes in rock tunnels

B. Definitions:
1. Contact grouting: Injection of grouting material at crown areas of tunnels to fill voids between tunnel lining and surrounding rock.
2. Consolidation grouting: Injection of grouting material through holes drilled up to 25 feet long at appropriate intervals around periphery of rock tunnel prior to installation of lining.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A53, C109, D1785, D2466.

B. Qualifications:
1. When taking rock cores, employ only experienced rock core-drilling personnel.

C. Tests:
1. Determine strength of cementitious grout from test specimens made and tested in accordance with ASTM C109.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Working Drawings:
   a. Details of grout mix composition. Submit prior to grouting.
2. Documentation:
   a. Rock core logs prepared as approved. Submit daily.
      1) Include descriptions as follows:
         a) Materials of whatever character encountered in drilling and their locations in the holes.
         b) Length of each run with percentage of core recovery.
         c) Location of special features such as mud seams, open cracks and soft or broken ground.
         d) Points where abnormal loss or gain of drill water has occurred.
         e) Groundwater levels or other items of interest in connection with grouting in exploratory drilling.
         f) Significant actions of bit and reasons for loss of core.
3. Rock Cores:
   a. Place entire rock cores in boxes in same order they are recovered from each hole. Use wooden blocks to show lengths of core not recovered.

b. Mark core boxes with number of boring and depths from which cores are recovered.
c. Include the following information:
1) Percentage of core recovered compared with actual depth of drilling necessary to obtain sample.
2) Rock quality designation (RQD) for each core run.
d. Deliver cores to Engineer as directed.

1.04 JOB CONDITIONS:

A. Grouting Records:
1. Cooperate with and assist the Engineer in keeping records of grouting operations including time of each change in grouting pressure, rate of pumping, amount of cement for each change in water-cement ratio and other necessary data.

B. Start Date:
1. Notify the Engineer at least one week prior to beginning grouting operations

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Cement: Section 03300, Type II.

B. Water: Potable.

C. Admixture: For plasticizing or retarding as approved.

D. Fine Aggregate:
1. As specified in Section 03300, with the following additional requirements:
a. 100-percent passing U.S. Standard sieve Number 16.
b. Graded as follows for contact grouting:

U.S. Standard Sieve Size	Percent Passing
16	100
30	65 - 90
50	20 - 60
100	5 - 15
200	0 - 15

E. Grout Pipe and Fittings: ASTM A53, standard weight, Schedule 40, black.

F. Plastic Drain Pipe: PVC, ASTM D1785 and ASTM D2466, Schedule 40.

G. Core Boxes:
1. Wood fabrication, sufficiently strong to withstand handling and transportation.
2. Size: Forty-eight inches by nine inches by three inches.
3. With solid-wood dividing strips, not plywood, to separate cores.

2.02 GROUT MIXES:

A. Grout for Contact Grouting:
   1. Consisting of one part portland cement, one part fine aggregate and approved admixture or as otherwise approved.
   2. Minimum compressive strength: 100 psi within 24 hours.
   3. Fluid enough to be injected to fill voids.
   4. Comprising ingredients not corrosive to steel.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. For exploratory core drilling, use approved drilling equipment with double-tube core barrel to obtain continuous NX, minimum size cores, 2-1/8 inches diameter.

B. For feeler, grout and drain holes, use rotary or percussion-drilling equipment.

C. For pumping grout, use approved pump capable of developing appropriate, approved, uniform pressure at grout hole connection and hoses with inside diameter of 1-1/2 inches minimum.

D. Use horizontal shaft paddle or colloidal pump mixer with minimum capacity of 20 cubic feet and with accurate meter which reads to nearest 1/10-cubic foot for measuring amount of mixing water added to grout.

E. Provide approved pressure gauges at grout pump and on manifold hookup at collar of hole being grouted.

3.02 FEELER HOLES:

A. Drill feeler holes as directed ahead of excavation to determine in advance nature and condition of materials to be excavated.

B. Drill each hole to diameter of 1-1/2 inches minimum and length of 15 feet minimum and 30 feet maximum.

C. While drilling feeler holes, suspend or modify other operations as necessary to permit such drilling. Drill holes only in the presence of the Engineer.

D. Obtain approval for location, direction, length and number of holes.

3.03 EXPLORATORY HOLES:

A. Drill exploratory holes in order to determine type and quality of rock.

B. Depending on nature of rock, select length of drill run to ensure maximum core recovery, but in no case to exceed five feet.

C. Package cores as specified and deliver to the Engineer as directed.

D. Unless otherwise directed, pressure grout exploratory holes after removal of core.

3.04 DRAIN HOLES:

A. Locate and drill holes where shown or as directed. Keep holes clear of obstructions.

B. Use plastic pipe for weep holes where shown. Fasten fittings with adhesive or threads.

3.05 GROUTING:

A. General Requirements:
1. Grout holes:
   a. Drill grout holes in rock or lining to diameter of two inches minimum and as shown or as directed or use existing grout holes.
   b. Avoid cutting embedded steel. If steel is encountered, cease cutting and patch hole.
   c. Clean obstructed holes for entire depth prior to grouting.
   d. Thoroughly wash grout holes immediately before starting pressure grouting.
2. Pipes and fittings:
   a. Place pipes to be embedded in tunnel lining for contact-grout connections and air vents as shown.
   b. Set inner end of pipes not less than two inches back from finished inside surface and provide recesses from there to surfaces of lining. Fill recesses with concrete or mortar after grouting operations have been completed.
   c. Set grout pipes so that grout flows freely to voids behind lining.
   d. Hold pipes to be embedded firmly in position and protect from damage while concrete is being placed. Provide and attach caps or other devices to ends of pipe to prevent entry of concrete or other foreign materials prior to grouting and to facilitate location of grout pipe after forms are removed.
   e. Avoid clogging or obstructing pipes before grout hookups are made. Clean clogged or obstructed pipes.
3. Connections:
   a. Make connections so as to prevent leakage.
   b. Remove plugs on ends of grout holes or pipes to permit escape of air and water and filling of spaces with grout.
   c. Provide straightway cock or valve at each connection.
4. Grouting operations:
   a. Perform grouting operations in the presence of the Engineer.
   b. Use grout of consistency to suit the characteristics of the hole being grouted or the type of grouting being performed.
   c. Use approved pressure at hole.
   d. Consider grouting hole to be complete when hole refuses grout at 90 percent of highest pressure approved.
   e. Upon completion of grouting at each connection, close valve and leave it in place until grout has set.
   f. After grout has set remove valves and fittings and metal connections to depth of 1-1/2 inches minimum from face of concrete.
   g. Fill grout holes with thick grout or dry pack at completion of grouting operations to leave smooth finished surface.
   h. Do not block drains or drain lines during grouting operations.
   i. Clean drains after each grouting operation.

B. Consolidation Grouting:
1. Perform consolidation grouting as necessary.
2. If consolidation grouting has to be performed after contact grouting, allow at least seven days to elapse between completion of contact grouting and beginning of consolidation grouting.
3. Perform consolidation grouting within radius of 50 feet of cast-in-place concrete tunnel lining only when lining is more than 14 days old.

C. Contact Grouting:

1. Perform contact grouting through holes drilled or placed in tunnel lining where shown.
2. Obtain approval of grouting pattern and order of grouting prior to start of contact grouting.
3. Provide vent pipes to suit conditions encountered.
4. Perform contact grouting behind concrete liner when concrete is more than 14 days old.
5. Use maximum pressure for contact grouting as approved.
6. Continue grouting until clear grout stream emerges from vent pipe.
7. Allow at least seven days after completion of contact grouting, before beginning further grouting.

END OF SECTION

SECTION 02515

WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing water mains.

B. Related Work Specified Elsewhere
1. Grading, excavating and backfilling: Section 02320.
2. Maintenance, support and restoration of utility facilities: Section 02270.
3. Grounding and bonding: Section 16060.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Certification:
1. Proof that the water sampling and testing laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories
2. Proof that the independent laboratory is approved by the EPA or jurisdictional health authority.
3. Certified results of the specified Post-Sterilization Water Test.

B. Documentation:
1. Bill of materials for material which will be supplied by operating agency. *1

C. Working Drawings: *2
1. Complete detailed working drawings of the proposed fire hydrants. Approval of drawings submitted does not constitute a waiver of the requirements of the Contract, nor is the Authority compelled to accept hydrants unless they pass specified tests and requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: M36, M153. *3
3. AASHTO: M153. *4
4. ANSI/AWWA: C104/A21.4, C110/A21.10, C111/A21.11, C151/A21.11, C151/A21.51.
5. ASTM: A36, A48, A53, B88, C33.
6. ASTM: A36, A48, C33, C76. *5
7. ASTM: A36, A48, C33. *6
8. ANSI/AWWA: C108, C151, C500, C502. *7

9. ANSI/AWWA: C151, C200. *8
10. EPA: National Primary Drinking Water Standards.
11. WSSC: General Conditions and Standard Specifications, Standard Fire Hydrant Drawings. *9

B. Allowable Tolerances:
1. Leakage not to exceed figures given in Table 02515-1.
2. Lead concentration in specified water samples less than 15 micrograms per liter of water, and water quality meets the requirements of EPA National Primary Drinking Water Standards.

C. Testing Laboratory:
1. Furnish services of an EPA-certified or jurisdictional health agency-certified independent laboratory for sampling and testing water quality. Employment of an independent laboratory does not relieve Contractor of the obligation to perform work in accordance with Contract requirements.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Upon approval of bill of materials, pick up material at designated storage facility and transport to job site. *9

B. To reduce handling to a minimum, coordinate pipe delivery with installation.

C. Distribute pipe along line of work and outside trench as near as practicable to point of placement. Do not deposit material on or against pipe.

D. Arrange and install skids and wedges to prevent damage to pipe. Do not roll or drag pipe.

E. Avoid damage to coating and lining; use handling equipment designed for the purpose. Where approved, pipe may be handled by hand.

F. When pipe installation is not actually in progress, place watertight caps or plugs on open pipe ends.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate No. 4 or where directed No. 4 and No. 67 in combination and proportions to suit field conditions.

B. Aggregate for Fire Hydrant Dry Wells: ASTM C33, coarse aggregate, No. 67.

C. Ductile Iron Pipe:
1. ANSI/AWWA C151/A21.51.With standard cement-mortar lining with bituminous seal coat conforming to ANSI/AWWA C104/A21.4.
2. Furnished in uniform standard lengths. Short pipe lengths and fittings are permitted where line, grade and closure requirements necessitate.

D. Joints:
   1. ANSI/AWWA C151/A21.11.
   2. Where shown as DILM, use mechanical joint ductile iron pipe. Where shown as DILS, use push-on joint. Unless otherwise shown, ductile iron pipe joints may be either mechanical joints or push-on joints.

E. Fittings:
   1. ANSI/AWWA C110/A21.10 as modified.
   2. Suitable for use with ductile-iron pipe; designed for 250 psi working pressure.
   3. Furnished with coating and lining as for ductile iron pipe, with mechanical joint, except that offsets will have one plain spigot end.

F. Gasket Lubricant: For mechanical joints: Approved vegetable oil soap. For push-on joints: Approved gasket lubricant supplied by the pipe manufacturer and conforming to ANSI/AWWA C111/A21.11.

G. Concrete: Section 03300, Class 3500.

H. Mortar: Section 02535.

I. Brick: Section 02535.

J. Reinforcing Steel and Welded Steel Wire Fabric: Section 03200.

K. Precast Concrete Elements: Section 03400, Class 4000, air-entrained concrete.

L. Steps: ASTM A48, Class 30.

M. Manhole Frame and Cover; And Other Castings For Service With Utility Systems:
   1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
   2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
   3. Rust-resistant cast iron or rust-resistant malleable cast iron.
   4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
   5. Fillets at angles in casting with arises sharp and perfect.
   6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
   7. Metro logo: For utility components which will remain METRO property and are not within boundaries of utility easements as shown: Cast METRO logo as shown.
   8. Covers that receive paver tile:
      a. Omit bituminous coating.
      b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position

N. Piling for Thrust Blocks and Steel for Structural Use: ASTM A36.

O. Resilient Material at Pipe Penetrations: AASHTO M153, Type II. See Section 02320.

P. Vitrified Clay Pipe: Section 02535.

Q. Backfill: Section 02320.

R. Valves: Built and tested in accordance with ANSI/AWWA C500.

1. Cast-iron body, bronze-mounted, parallel-seat, double-disc gate valves with nonrising stems, nut-operated to open counterclockwise to withstand and operate under a working pressure of 150 pounds per square inch.

2. Mechanical joint or flanged ends as shown and manufactured by American Darling Valve and Manufacturing Company, Ludlow-Rensselaer Valve Company or equal.

3. No gearing or bypass will be required on valves smaller than 16 inches.

4. Valves 16 inches and larger equipped with a bypass and bevel gearing for horizontal installations or spur gearing for vertical installations.

S. Valves: In accordance with requirements of the operating agency. *10 and *9

T. Materials Supplied by the Operating Agency: *11 *and* *9 1.

1. Except for those items which bear the METRO logo, the WSSC furnishes the following:
   a. Water meter, meter frame and cover, meter housing, copper and brass pipe and fittings for meter settings, and adjustable valve box.

U. Materials Supplied by Operating Agency: As specified. *12 and *9

V. Yard Hydrant: Cast-iron box with lid, freeze proof valve with removable handle and threaded hose connection, hose bib size 2-1/2 inches, service pipe size as shown, Josam Series 71600 or equal.
Coal-tar epoxy: Section 02535.

W. Bituminous Coating: ANSI/AWWA C151. *13

X. Steel Pipe Casing: ASTM A53, Grade B, ungalvanized. *14

Y. Casing pipe: *15

1. Reinforced concrete: ASTM C76, Class IV.
2. Corrugated metal: AASHTO M36, 8-gauge, galvanized, asphalt coated.
3. Seamless steel: Black, welded, mill type, ANSI/AWWA C200.

Z. Fire Hydrants: Conforming to ANSI/AWWA C502, and WSSC's Standard Fire Hydrant Drawings with the following additional requirements: *16

1. Interchangeable with existing WSSC fire hydrant. A sample fire hydrant similar to those now in use will be available at the Warehouse at 3500 Kenilworth Avenue, Bladensburg, Maryland, for inspection and comparison.
2. Manufactured by Kennedy Valve Mfg. Company, Elmira, N.Y. or equal, including name of manufacturer and year of manufacture cast in raised letters.

3. Barrel sections:
   a. Two cast-iron sections, with hollow or breakable flange at least two inches above finished grade line, cast iron conforming to ANSI/AWWA A21.8/C108).
   b. Lower section of barrel: Static casting with an integral tapered top flange seat. Nozzle section attached to lower barrel section by means of a tapered flange ring held in place by six hydrant-head bolts and nuts.
   c. Flange and flange rings: Top or nozzle section, including bonnet and operating nut, revolving 360 degrees for facing without disturbing bottom section of barrel. The use of split bronze insert ring is prohibited.
   d. Hydrant: Barrel, complete with the working parts, including main and drain valve seats, removable for inspection or repair and replaceable without disturbing the ground.
   e. Depth of bury of the hydrant indicated in raised figures on barrel, showingdepth in feet. Figure on barrel just below the swivel flange and above protective case, visible when installed. Figure raised at least 1/8-inch above barrel surface and height of the figure at least one inch, integrally cast with barrel.
4. Frost case:
   a. Cast-iron, two-piece lower section may be centrifugally cast and 12 inches shorter than depth of bury.
   b. The upper section of frost casing normally furnished in lengths of nine inches, but sections both 15 and 21 inches long furnished as required to be used for maintenance purposes where longer hydrant barrels have to be replaced on existing installations.
5. Main valve:
   a. Main valve seat: Compression type, opening against pressure.
   b. Valve: Faced with Balata.
6. Discharge nozzles:
   a. One 4-1/2 inch pumper and two 2-1/2 inch hose nozzles, both pumper and hose nozzle threads conforming to the requirements of ANSI specifications for National (American) Standard fire hose coupling screw thread.
   b. Nozzle caps: For outlets, attached to the fire hydrant by means of suitable chains.
   c. Hose nozzles of bronze and leaded into the barrel.

7. Elbow or inlet connections:
   a. Cast-iron hydrant barrel to screw into the elbow. Elbow fitted with removable or replaceable threaded bronze ring to receive hydrant barrel.
   b. Inlet connection: Six inches, Class 350, mechanical joint bell, meeting the general requirement for Standard Mechanical Joint Cast-Iron Pipe and Fittings with the necessary accessories for each such mechanical joint.
   c. Bolts: Low-alloy steel, Corten, Usaloy or equal.
   d. Gaskets: Rubber.
   e. Glands: High-strength cast iron consistent in design with elbows with which they are to be used.

AA Copper Tubing: ASTM B88, Class I, Type K, hard-drawn. *17

BB Metro Logo: For utility components which remain property of the Authority and are not within the boundaries of utilities' easements indicated in the Right-of-Way drawings, use cast METRO logo as shown. *18

CC Oak Chock: Undressed, clear, four inches wide by 18 inches long, height variable, with recessed groove, 1-1/16 inches by 1/4-inch deep, centered across four-inch dimension. *19

DD Metal Band: Steel, one inch by 0.035 inch. *20

PART 3 - EXECUTION

3.01 MAINTAINING WATER SERVICES:

A. Maintain water service in accordance with Section 02270. In furtherance of this requirement, conduct operations at times selected to minimize duration and inconvenience of service interruption.

B. At least 24 hours prior to cutting or abandoning an existing water main, notify the Engineer and operations division of operating agency and obtain approval of schedule for performance of work. *9

C. Keep existing water mains parallel to new water mains in service until new water mains are ready for service.

D. Where existing water main must be cut for connection to new water main, provide necessary facilities and prosecute work on 24-hour basis.

E. Water valves in service will only be operated by personnel of the agency owning main. *9

3.02 EXCAVATION:

A. Perform excavation to line and grade in accordance with Section 02320 with the following additional requirements:

1. Excavate test pits sufficiently in advance of construction so that reasonable changes in line and grade can be made where the location of existing structures varies from that shown.
2. Excavate below horizontal plane extending two feet above top of water main structure to such width that construction may be properly performed, but not less than six inches nor more than nine inches from outside of proposed structure.
3. Excavation above such plane may exceed specified dimensions where approved.
4. If excavation exceeds permissible dimensions, install pipe of higher strength as directed.
5. Unless otherwise shown, install pipe in excavated trenches. Trench to have such depth that there will be at least two feet of trench of required width above top of pipe.
6. Where necessary to place backfill or embankment so that trench can be excavated, extend and compact backfill or embankment to full depth and laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

3.03 SUBGRADE:

A. Prepare subgrade so that pipe will rest solidly throughout its length. Excavate recesses to accommodate joints and fittings.

3.04 BACKFILL:

A. Backfill excavation upon completion of construction in accordance with Section 02320.

B. Perform backfilling after inspection and approval of pipe laying.

3.05 LAYING PIPES:

A. Take proper measures to keep pipe clean. Immediately prior to placing, clean inside and ends of outside surfaces of pipe. Keep interior surfaces clean throughout construction.

B. Prior to placing pipe in trench, have interior and exterior inspected. Where there is damage that the Engineer determines repairable, make repairs as directed. Replace pipe damaged beyond acceptable repair.

C. Complete excavation and placing of subgrade before pipe is placed. Place pipe solidly true to line and grade shown. Do not subject pipe to blows or shocks to achieve solid bedding or proper line and grade.

D. Make change in line with fittings. Do not spring joints to effect change of direction.

E. Do not field cut pipe unless necessary. Make such necessary cuts by means of equipment designed for purpose, ensuring smooth square end.

F. For connection to existing pipe, provide pipe with suitable ends or adaptors, after verification of size and type of existing pipe.

G. For railroad and highway crossings, lay casing and water mains as shown. *21

H. Place oak chocks as shown, fasten metal band to chocks as approved. Space chock arrangements on water mains at six feet zero inches on center. *22

I. After water main is in place, fill void between main and casing with sand. *23

J. Close ends of casing pipe with brick masonry enclosure as approved. *24

3.06 ASSEMBLING MECHANICAL JOINTS:

A. Assemble mechanical joints to provide tight, flexible joints that safely permit expansion, contraction and ground movement.

B. Prior to assembling mechanical joints, wire brush surfaces of pipe sections in contact with gasket so that surfaces are clean, smooth and free of rust and other foreign substances. Clean and lubricate contact surfaces with vegetable oil.

C. Assemble mechanical joints in accordance with ANSI/AWWA C111/ A21.11.

D. Furnish to the Engineer calibrated torque wrenches in sufficient number to permit complete inspection of work. Provide satisfactory means of recalibration.

E. If satisfactory seating of joint is not obtained at maximum permissible torque, disassemble joint, reclean and reassemble with new gasket.

3.07 ASSEMBLING PUSH-ON JOINTS:

A. Assemble push-on joints to provide tight, flexible joints that safely permit expansion, contraction and ground movement.

B. Assemble joints using lubricant in accordance with recommendations by pipe manufacturer.

C. File or grind spigot of field-cut pipe lengths to resemble manufactured pipe so that spigot end will slip into socket without hindrance or gasket damage.

D. Place identifying mark on pipe not bearing depth mark on spigot to show depth of socket.

3.08 VALVES:

A. Install valves in accordance with recommendations of the valve manufacturer.

B. Where valves are provided by operating agency, provide suitable access for performance of work. *9

C. Where necessary, alter typical valve manhole to suit actual conditions.

3.09 SUCTION OUTLETS:

A. Construct suction outlets where shown.

B. Provide necessary materials not furnished by operating agency to complete installation. *9

3.10 DEAD-END BLOWOFFS:

A. Provide tapped and drilled caps for dead-end blowoffs where shown.

B. Complete construction of dead-end blowoffs. Provide materials not furnished by operating agency but necessary to complete installation. *9

3.11 FIRE HYDRANTS:

A. Construct fire hydrant installations as shown.

B. Provide necessary materials not furnished by operating agency to complete installation. *9

C. Shop Painting: *25

1. Clean outside of hydrant above finished ground line and give two coats of paint as manufactured by Grow Chemical Coating Corp., Tropical Paint Division, 1250 West 70th Street, Cleveland, Ohio 44102, or equal. The bonnet of the hydrant painted with Rhinamel Forest Green No. 202-97-I.F. or equal and the body and outside of the top section frost casing painted with Rhinamel Gray No. 202-21-00 or equal

2. Bituminous Coating: Paint the barrel below the ground line, the bottom section of the frost casing and the cast-iron elbow, inside and outside. Paint only the inside of the top section of frost casing.
   a. The bituminous coating to be smooth, tough and tenacious coating, neither so soft as to flow when exposed to sun nor so brittle as to crack and scale off when exposed to temperature below freezing, and not deleterious to potable water.
   b. Apply the bituminous coating hot or cold either by brushing, dipping or spraying. The coating material to be subjected to chemical and physical tests by the Engineer to confirm its uniformity and quality.
   c. Examine surfaces for peeling or scaling. Repair damage to the coating because of rough handling or rubbing in shipping and restore coating to its original condition.

3.12 THRUST BLOCKS AND HARNESSING:

A. Make provision for counteracting thrust caused by static and dynamic forces including water hammer at bends, tees, reducers, valves and dead-ends by installing ductile iron retainer glands with mechanical joints. For other methods submit details for approval prior to use.

B. Install concrete thrust blocks as shown where harnessing is not practicable.

C. Where shown provide piles and reinforcing steel in concrete thrust blocks. Install piles for thrust blocks to bearing of 15 tons.

3.13 CAST-IN-PLACE CONCRETE CONSTRUCTION:

A. Conform to applicable requirements of Sections 03100, 03200 and 03300.

3.14 PRECAST CONCRETE CONSTRUCTION:

A. When installing precast sections, prevent damage to seals and sealants.

3.15 BRICK CONSTRUCTION:

A. Conform to applicable requirements of Section 04215.

3.16 WATER SERVICE CONNECTIONS:

A. Construct water mains and water service connections in accordance with the codes and regulations of the jurisdictional agency. *26

B. Make water service connections, where necessary, in accordance with applicable plumbing code. *27

C. Pay the required by the jurisdictional agency, except the water availability charge, which will be paid by the Authority. *28

D. Pay the water consumption charges until the time of final substantial completion for this Contract. *29

E. Do not connect water service to WSSC system until application for the connection has been approved by the WSSC. *30

F. Pay the water consumption charges until the time of final substantial completion for this Contract. *31

3.17 TUNNELING AND JACKING:

A. Perform tunneling and jacking as approved.

B. Where open cut is specified and the Engineer permits work to be done by tunneling or jacking, perform such work as specified and as approved.

C. Make horizontal borings for laying pipe lines true to line and grade.

D. Where pipes are laid in borings, completely fill void between pipe and the boring with sand, using water pressure to ensure that voids are filled.

E. Methods of boring and filling of voids between pipe and boring and subject to approval.

3.18 BONDING AND CATHODIC PROTECTION:

A. Bond ferrous pipe in accordance with Section 16060.

B. Where cathodic protection of piping system is shown, apply coal-tar epoxy coating as specified in Section 02535 and test as specified in Section 13115.

3.19 FIELD QUALITY CONTROL:

A. Notice of Testing:

1. Coordinate with and assist the WSSC in testing water mains. Provide equipment necessary for and adequate to maintain required pressures for the required period. Do the work, such as making connections, operating pump, providing piping, valves and other materials necessary for making tests. Pressure recorder, charts and water meter for testing will be furnished by the WSSC. *32
2. Give two days notice of intention of testing to operating agency which will furnish, install and operate pumps, gauges, meters and individual pipe connections to test openings. *33 *and* *9
3. Designate largest sections feasible for testing and sterilizing. One testing and sterilizing operation will be performed at no expense to the Contractor; the cost of subsequent testing and sterilizing, if necessary, will be borne by the Contractor. *9

B. Tests:

1. General requirements:
   a. Prior to coating and backfilling, isolate system by use of approved valves, caps and plugs or other means.
   b. Maintain such isolation throughout performance of leakage and pressure testing.

c. Where valves are used for isolation, eliminate leakage through such valves if it occurs. Maintain new work isolated from existing water mains, except for test connections, until testing and sterilization have been completed.

2. Leakage test:

a. For leakage tests, provide approved caps and plugs in sections to be tested and remove them after testing.

b. Prevent leakage in pipes and fittings at openings.

c. Block temporarily plugged and capped ends to prevent displacement.

d. Install water source connection for testing isolated section; the Engineer may permit the use of tap which will be furnished and installed by operating agency. *9

e. Perform work and furnish materials incidental to leakage testing, including excavation for installation and removal of pumps, gauges, meters and water source connections. Operating agency will apply 125-psig test-pressure section under test for 24 hours minimum. *9

f. Where leakage exceeds the amount specified in Table 02515-1, perform necessary corrective measures.

g. Pressure test:

1) After completion of leakage test, remove temporary caps and plugs and connect new water main into system. With new work valved off or otherwise isolated from system by approved means, assist with pressure test.

2) Operating agency will apply 175-psig test-pressure to section under test for one-hour minimum. *9

3) Take corrective measures necessary to provide system free of leaks.Remove and replace defective pipes, jointings, fittings, valves and other appurtenances. Reset such items, if displaced.

3.20 STERILIZING:

A. Operating agency will sterilize work during leakage test. *9

B. Provide access to opening used for sterilizing.

C. Provide Post-Sterilization Water Sampling and Testing Services: Have EPA-approved or jurisdictional health authority-certified laboratory sample and test water, and submit certified test results that water quality and lead concentration in samples meet EPA standards.

3.21 COMPLETION:

A. Upon completion of leakage testing and sterilizing remove temporary construction and complete connection of new work to system.

B. Bond ferrous pipe in accordance with Section 16060.

C. Have EPA-approved or jurisdictional health authority-certified laboratory sample and final proof-test water, and submit certified test results that water quality and lead concentration in samples meet EPA standards.

THIS SPACE NOT USED.

TABLE 02515-1

MAXIMUM ALLOWABLE LEAKAGE IN CUBIC FEET PER 24 HOURS PER JOINT

Test Pressure	Nominal Pipe Size											
psi	6"	8"	12"	16"	20"	24"	30"	36"	48"	60"	66"	72"

100	.052	.069	.104	.139	.173	.208	.260	.312	.416	.520	.572	.624
110	.054	.073	.109	.145	.181	.217	.272	.326	.435	.544	.598	.652
120	.057	.076	.114	.152	.190	.228	.285	.342	.456	.570	.627	.684
130	.059	.079	.119	.158	.197	.237	.296	.356	.474	.593	.652	.711
140	.062	.082	.123	.164	.205	.246	.308	.369	.492	.615	.677	.738
150	.064	.085	.127	.170	.212	.255	.318	.382	.509	.637	.701	.764
160	.066	.088	.132	.175	.219	.263	.329	.395	.526	.658	.724	.789
170	.068	.090	.136	.181	.226	.271	.339	.407	.542	.678	.746	.814
180	.070	.093	.140	.186	.232	.279	.349	.419	.558	.698	.767	.837
190	.072	.096	.143	.191	.238	.287	.358	.430	.573	.717	.788	.860
200	.074	.098	.147	.196	.245	.294	.368	.441	.588	.735	.809	.882
psi	6"	8"	12"	16"	20"	24"	30"	36"	48"	60"	66"	72"
Above tabulation is based on leakage at maximum rate of 23.3 gallons per inch of pipe diameter per mile per 24 hours at 150 psi for pipe in 18-foot lengths.												

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Delete or modify this paragraph as appropriate when project does not involve an operating agency.

***2**. Add 1.2 C. including 1. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***3**. Use first version of 1.3 A.2. modification for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***4**. Use second version of 1.3 A.2. for contracts where water distribution work is performed in all other jurisdictions.

***5**.. Use second version of 1.3 A.4. modification for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***6**. Use third version of 1.3 A.4. modification for contracts where water distribution work is performed in all other jurisdictions.

***7**. Add first version of 1.3 A.5. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***8**. Add second version of 1.3 A.5. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***9**. Add 1.3 A.7. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***10**. Use second version of 2.1 R. for contracts where water distribution work is performed outside the jurisdiction of WSSC.

***11**. Use first version of 2.1 S. including 1.a. modification for contracts where water distribution work is performed within the jurisdiction of WSSC.

***12**. Use second version of 2.1 S. for contracts where water distribution work is performed outside the jurisdiction of WSSC.

***13**. Add 2.1 V. for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***14**. Add first version of 2.1 W. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***15**. Add second version of 2.1 W. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***16**. Add first version of 2.1 X. including 1.-7.e. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***17**. Add second version of 2.1 X. including 1.-3. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***18**. Add first version of 2.1 Y. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***19**. Add second version of 2.1 Y. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***20**. Add 2.1 Z. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***21**. Add 3.5 G. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***22**. Add 3.5 H. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***23**. Add 3.5 I. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***24**. Add 3.5 J. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***25**. Add 3.11 C. including 1.-2.c. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***26**. Use first version of 3.16 A. modification for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.

***27**. Use second version of 3.16 A. modification for contracts where water distribution work is performed in all other jurisdictions.

***28**. Add 3.16 B. for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.

***29**. Add first version of 3.16 C. where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.

***30**. Add second version of 3.16 C. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***31**. Add 3.16 D. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***32**. Use first version of 3.19 A.1. modification for contracts where water distribution work is performed within the jurisdiction of WSSC.

***33**. Use second version of 3.19 A.1. modification for all other contracts where water distribution work is performed.

END OF SECTION

SECTION 02535

SANITARY SEWER

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies installing sanitary sewers.

B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Maintenance, support and restoration of utility facilities: Section 02270.
3. Stray current and cathodic protection: Section 13110 and 13115.

C. Material Furnished By Others: *1
1. Except for those items which bear the METRO logo, WSSC furnishes the following:
   a. Manhole frames and covers: 22-inch diameter.
   b. Manhole steps, except where precast manholes are used.

D. Definitions: *2
1. Granular bedding required by WSSC is equivalent to aggregate for pipe cradle as specified.
2. WSSC: Washington Suburban Sanitary Commission.
3. WASA: Water and Sewer Authority.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Drawings for each size and configuration of precast manhole with details of accessories and joints.
   b. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.
2. Documentation:
   a. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.
3. Samples:
   a. Sewer brick: Ten.
   b. Manhole brick: Ten.
4. Certification.
5. Documentation: *3
   a. Submit two copies of records of inspection of new and relocated sewers, one copy to WSSC and one copy to the Engineer. Include video-tape cassette of television inspections and logs, photographs and other records specified by WASA for visual walk-through inspections.
   b. Obtain and submit a written approval and acceptance from WASA.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. Building Stone Institute: Stone Catalog
3. CISPI: HSN 85.
4. AASHTO: M33, M153, T85, T96, T104. [*4]
5. AASHTO: H20, M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. [*5]
6. ANSI/ASME: B16.1. [*6]
7. ACI: 318.
8. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D1682, D3034. [*7]
9. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D3034, D5034. D5035. [*8]
10. MS: MIL-P-23236.
11. SSPC: SP-6.
12. WSSC: General Conditions and Standard Specifications. [*9]

B. Allowable Tolerances:
1. Rate of infiltration into sanitary sewer lines not to exceed 100 gallons per inch diameter per 24 hours per mile of sewer.
2. Subgrade: Plus-or-minus 1/2 inch of elevation shown.

C. Inspection: [*10]
1. Prior to paving or other construction over new or relocated sewers, conduct visual walk-through inspection of sewers larger than 36 inches in diameter and of associated structures and internal television inspection of sewers 36 inches and smaller in diameter.
2. Employ the services of a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to WASA to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter.
a. Submit to WASA for prior approval one sample of the cassettes to be used.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Portland Cement Concrete: Section 03300, Class 3500, unless otherwise shown.

D. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4. Where shown use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.

E. Aggregate for Pipe Cradle: ASTM C33, coarse aggregate No. 67.

F. Concrete Pipe:
1. 10-inch diameter and smaller:
a. STM C14, Class 2, nonreinforced concrete pipe.
b. Bell-and-spigot type.

c. Joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.

2. 12-inch diameter and larger:
   a. ASTM C76, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
   b. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
   c. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
   d. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
      1) 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
      2) Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.
      3) Minimum laying lengths:
         (a) Sanitary sewer and combined system construction:
         (b) 72-inch diameter and smaller: Eight feet.
         (c) Larger than 72-inch diameter: Six feet.
   e. Rubber gaskets: ASTM C361. *11
   f. Rubber gaskets: ASTM C443. *12
   g. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
      1) When applied to a vertical metal surface and heated to 120F, jointing mastic will neither slump nor lose plasticity.
      2) When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20F to 100F.

G. Plastic Pipe:
   1. Polyvinyl chloride (PVC) pipe: ASTM D3034, SDR-35.

H. Vitrified Clay Pipe: ASTM C700; Joints, ASTM C425, using plastic materials.

I. Cast-Iron Soil Pipe and Fittings: ASTM A74, extra-heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets conforming to CISPI Designation HSN 85 and the requirements of the relevant plumbing codes.

J. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.

K. Mortar Materials:
   1. Portland cement: ASTM C150, Type I.
   2. Sand: ASTM C144, natural sand.
   3. Lime: Pressure-hydrated, ASTM C207, Type S.
   4. Water: Potable.
   5. Pigment: As approved.

L. Brick: ASTM C32; solid brick; Grade MS for manhole brick, Grade SS for sewer brick; 2-1/4 inches by 3-3/4 inches by eight inches.

M. Precast Concrete Manhole Sections: *13
   1. ASTM C478.
   2. Joint entry seal gasket: A-LOK as manufactured by Atlantic Precast Concrete, Inc.; A-LOCK gaskets, manufactured by A-LOK Products Corporation, Trenton,

N.J.; DURAC-SEAL gaskets, manufactured by DURA-CRETE, Inc., Dayton, Ohio; or equal.

N. Precast Concrete Manholes: *14
1. Cylindrical, eccentrical and conical: ASTM C478.
2. Other configurations: ACI 318, AASHTO H20.

O. Manhole Steps:
1. Cast iron: ASTM A48 Class 30 A.
2. Rebar: No. 4 reinforcing bar with molded polypropelene or rubber encasement.

P. Manhole Frame and Cover; And Other Castings For Service With Utility Systems:
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
3. Rust-resistant cast iron or rust-resistant malleable cast iron.
4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
5. Fillets at angles in casting with arises sharp and perfect.
6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
7. Metro logo: For utility components which will remain METRO property and are not within boundaries of utility easements as shown: Cast METRO logo as shown.
8. Covers that receive paver tile:
   a. Omit bituminous coating.
   b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.

Q. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or equal.

R. Structural Steel Members: ASTM A36.

S. Steel Pipe: ASTM A53, black finish, extra strong wall class.

T. Stainless Steel Angle: ASTM A167, Type 304.

U. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.

V. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.

W. Bituminous Expansion Joint Filler: AASHTO M33.

X. Galvanizing: Section 05120.

Y. Miscellaneous Metal: Section 05500.

Z. Coal-Tar Epoxy Coating:
1. Two-component.
2. Chemically cured.
3. Conforming to MS MIL-P-23236 (Ships), Type I, Class 2.
4. Thinner: As recommended by manufacturer of coating and as approved.

AA. Pipe Supports: *15
1. Pipe: Three-inch diameter, ASTM A53, Weight B, Class 1.

2. Flanges: ANSI/ASME B16.1, 125-pound Class, galvanized after fabrication.

2.02 MORTAR AND GROUT MIXES:

A. General Requirements:
1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
2. Add sufficient water as specified to produce approved consistency.
3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
4. Do not retemper mix that has begun to set nor use such mix in the work.
5. Where shown, specified or directed, mix pigment into dry mix to attain color selected by the Engineer. Pigment not to exceed 10 percent of dry batch weight of cement.

B. Proportions:
1. Mortar: One part portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
2. Grout: One part portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.
3. Mortar for setting and pointing granite: One part portland cement, four to five parts sand, one part lime and water sufficient to produce approved consistency.
4. Mortar for setting granite paving and grouted granite blocks: One part portland cement, four parts sand, with water sufficient to produce approved consistency.

PART 3 - EXECUTION

3.01 EXCAVATION FOR SEWER:

A. Perform excavation for sewers line and grade shown in accordance with Section 02320 and the following additional requirements:
1. Excavate test pits sufficiently in advance of construction of sewers so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.
2. Excavate below horizontal plane extending two feet above top of sewer to maximum width of trench pay width shown. Where dimensions are not shown, make maximum horizontal width of excavation 18 inches from outside of sewer and minimum six inches. Where approved, excavation above such plane may exceed specified dimensions.
3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength.
4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

3.02 PIPE CRADLE:

A. Place pipes on cradle of aggregate or concrete where shown.

B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

3.03 LAYING PIPE:

A. General Requirements:

1. Excavate to lines and grades shown in accordance with Sections 02320 and herein. Excavate depressions for bells.
2. Protect pipe and fittings during handling to prevent damage.
3. Place, shape and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.
4. Start laying pipe at lowest point; lay true to line and grade shown.
5. Install pipe to bear on bedding material along entire length. Shape bedding material to fit bells and flanges.
6. Install pipe so that bells and grooves are on upstream end.
7. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.
8. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.
9. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.
10. Keep trenches and excavations free of water during construction and until backfilled. Each day, excavate only as much trench as needed to lay pipe.
11. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.
12. Where length of stub is not shown, install four-foot length and seal free end with brick masonry bulkhead or approved stopper.
13. Have work approved prior to covering pipe.
14. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding six inches loose. Compact each lift before placement of next lift.
15. Backfill in accordance with Section 02320.
16. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached three feet or half the pipe diameter, whichever is greater.
17. Where cathodic protection is shown, apply coal-tar epoxy coating.

B. Vitrified Clay Pipe:
   1. Nonperforated pipe:
      a. Use pipe hoist, crane or other approved device when laying pipe greater than 18 inches diameter.
      b. Prevent damage to premolded joint rings or attached couplings.
      c. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers or adhesives as recommended by pipe or joint manufacturer.

C. Concrete Pipe:
      a. Bell-and-spigot joints:
      b. Lay bell-and-spigot joint pipe as specified for vitrified clay pipe.
   1. Tongue-and-groove joints:
      a. Clean groove end of preceding pipe with wet brush and apply soft mortar to lower 1/4 of groove. Clean tongue end of succeeding pipe with wet brush and position it. Remove mortar from interior surface if squeezed out of joint.
      b. Complete mortaring interior and exterior portions of joint for entire circumference, extending from previously placed mortar. Perform final exterior mortaring of joints three lengths of pipe behind laying.

D. Plastic Pipe:
   1. Nonperforated pipe:
   2. Join sections of pipe with couplings recommended by pipe manufacturer.

E. Inspections Of Sewers: *16

1. Perform all work in accordance with current requirements of WASA.
2. Perform inspections on new or relocated storm, sanitary and combined sewers within or adjacent to the zone of influence, as defined by the limits of a theoretical slope of 1:1 from the bottom edges of tunneling and cut-and-cover excavations, as follows:
   a. Make inspections upon completion of tunneling and cut-and-cover operations, but prior to paving.
   b. Obtain video-tape television inspection records of sewers 36 inches and smaller in diameter.
   c. By means of visual walk-through inspection, obtain coordinated logs, photographs and other records specified by WASA sewers larger than 36 inches in diameter and of associated structures.
3. Coordinate all television and walk-through inspection field operations with WASA. All such work to be performed in the presence of a WASA representative.

3.02 BACKFILL:

A. Perform backfilling only after inspection and approval of pipe laying.

B. On completion of construction, backfill excavation in accordance with Section 02320.

3.03 JOINTS FOR COMBINED SEWER SYSTEM CONCRETE PIPE:

A. Use rubber gasket and bell-and-spigot pipe as specified.

B. Prior to jointing pipe, liberally coat pipe joints with lubricant.

C. Fit bell or spigot with gasket in accordance with manufacturer's instructions.

D. Joint pipes with equipment designed for purpose.

E. Before joint is completely home, check position of gasket using suitable gauge. If gasket is found to be dislocated, repeat entire joining process using new gasket.

3.04 JOINTS FOR VITRIFIED CLAY PIPE:

A. Immediately before joining vitrified pipe, liberally coat bell with lubricant and fit spigot with gasket.

B. Join pipes using equipment designed for purpose.

3.05 JOINTS FOR CAST-IRON SOIL PIPE AND FITTINGS:

A. Immediately before joining cast-iron soil pipe and fittings, liberally coat hub with lubricant and fit spigot with pipes using equipment designed for purpose.

3.06 CONNECTIONS WITH EXISTING SEWERS:

A. Make connections with existing public sewers in accordance with requirements of the jurisdictional authority.

B. Connect house sewers in accordance with local plumbing code.

C. Connect house sewers by means of Y-branches. Approved cast-iron thimble may be used, provided it is bonded into sewer pipe wall with approved epoxy at manufacturer's plant.

D. Do not connect existing sewer to sewer under construction unless approved.

E. Do not connect sanitary sewers to the WSSC system until application for such connections has been approved by WSSC. *17

3.07 TUNNELING AND JACKING:

A. Perform tunneling and jacking by approved methods.

B. Where open cut is specified and the Engineer permits the work to be done by tunneling or jacking, perform such work as specified and as approved.

C. Cost of material substitutions required by change of methods will be borne by the Contractor.

D. Make horizontal borings necessary to lay pipe lines true to line and grade.

E. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.

F. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.

G. Methods of boring and filling of voids between pipe and boring are subject to approval.

3.08 CAST-IN-PLACE CONCRETE CONSTRUCTION:

A. Conform to applicable requirements of Sections 03100, 03200 and 03300. Section designer to specify the type of cement to be used. The type of cement will vary depending upon the jurisdiction where the work is performed.
1. Cement. *18

B. Construct concrete support systems where shown. Section designer to specify the type of mortar to be used. Mortar type will vary depending upon jurisdiction in which the work is performed.
1. Mortar and cement. *19

3.09 BRICK CONSTRUCTION:

A. Perform brick construction as specified in Section 04215, with the following additional requirements:
1. Use sewer brick wherever brick construction is exposed to flow; otherwise, use manhole brick.
2. Lay sewer brick on edge so that 2-1/4 by 8-inch side is exposed to flow.
3. Lay manhole brick so that every sixth course is a header course.
4. Where practicable, lay each course with a line. For curved courses or those in nonparallel planes, use bonded-and-keyed construction.
5. Do not exceed joint thickness of 3/8 inch in straight courses in parallel planes; for courses curved or in nonparallel planes, make thickest part of joint as thin as practicable.

6. Rack or tooth uncompleted brick construction and parge unexposed surfaces with 1/2 inch of mortar.

3.10 MANHOLES:

A. Construct manholes of precast sections, cast-in-place concrete or brick as shown.

B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.

C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.

D. Construct appropriate flow channels in bottom of manholes.

E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.

F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.

G. Install joint entry seal gaskets in openings in the walls of 48-inch precast manholes with O-ring joint. *20

H.

3.11 COATING APPLICATION AND REPAIR:

A. Preparation of surface: Perform the following in order given:
1. Clean surfaces contaminated with oil or grease using naphtha or xylol.
2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP-6.
3. Coat surfaces within 24 hours and before dew point is reached.
4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.

B. Application of coating:
1. Mix coating in quantity which can be applied within its pot life if in accordance with manufacturer's recommendation. Thin only with approval.
2. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
   a. Two coats of equal thickness.
   b. Total dry film thickness: 20 mils.
   c. Pretreat first coat as required prior to application of second coat.
   d. Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
   e. Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.
3. Test cathodic protection as specified in Section 13115.

3.12 FIELD QUALITY CONTROL:

A. Maximum Surface Variation Tolerances:
1. Grouted riprap: 1-1/4 inches in four feet from true plane.
2. Bituminous concrete: Plus-or-minus 1/4 inch from specified grade in 25 feet.

3. Cast-in-place concrete: Plus-or-minus 1/4 inch from specified grade in 15 feet.
4. Precast concrete block: Plus-or-minus 1/2 inch from specified grade in 25 feet.
5. Paving brick: Plus-or-minus 1/2 inch from specified grade in 25 feet.

B. Leakage Tests:
1. Perform leakage tests on sanitary sewer lines to verify compliance with allowable tolerances specified.

C. Obstruction Tests:
1. Perform field tests to verify that installed storm and sanitary systems are free from obstructions.
2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Engineer.

D. Low-Pressure Air Testing Of Sanitary Sewers. *21
1. Test sanitary sewers with air under low pressure in accordance with WSSC procedures. The tests will not be accepted by the WSSC until the sewers meet the criteria enumerated. Pressure gauges, stop watches and test supervision will be provided by the WSSC. Provide air compressor, hose, plugs, labor and such materials, equipment and assistance required to perform the tests. Conduct tests in the presence of representatives of the WSSC. Do not place air under pressure in any sewer under any condition except those specified by WSSC.
2. Inspect sanitary sewers, including manholes, prior to air testing. Prior to undertaking the low-pressure air tests, correct and eliminate any water leakage into the system sufficient to constitute a noticeable trickle or dribble.
3. Wherever underdrains have been constructed or gravel placed under pipelines to dewater the trench during construction of the sewers, do not make air test until pumps used in the dewatering process have been removed from the site.
4. Before air tests are scheduled, complete backfill operations and compaction tests. Have compaction test approved before air tests are scheduled.
5. Schedule air tests with the WSSC at least 48 hours in advance. Test each section of completed sewers. Test sewers from manhole to manhole, or from manhole to terminus of the sewer if there is not a manhole at the other extremity. Do not exclude any sewers or sewer connections from this testing procedure.

3.13 TRANSPORTATION AND INSTALLATION OF MATERIALS FURNISHED BY OTHERS: *22

A. Transport and install materials furnished at the WSSC's storeyard at Bladensburg or other delivery points designated by the WSSC.

B. Use only suitable equipment, tools, and appliances for the safe and convenient handling and hauling of materials.

C. Check that all materials furnished by the WSSC are in satisfactory condition.

D. Materials damaged, lost or wasted after acceptance will be replaced by the WSSC at the expense of the Contractor.

E. Material showing inherent defects will be replaced by the WSSC without charge.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

1. Add 1.1 C. including 1.a.-b. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

2. Add 1.1 D. including 1. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

3. Add 1.2 E. including 1.-2. for contracts where sanitary systems work is performed within the jurisdiction of WASA.

4. Use first version of 1.3 A.4. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

5. Use second version of 1.3 A.4. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

6. Use first version of 1.3 A.5. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

7. Use first version of 1.3 A.6. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

8. Use second version of 1.3 A.6. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

9. Add 1.3 A.9. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

10. Add 1.3 C. including 1.-2.a. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

11. Use first version of 2.1 F.2.f. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

12. Use second version of 2.1 F.2.f. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

13. Use first version of 2.1 N. including 1.-2. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

14. Use second version of 2.1 N. including 1.-2. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

15. Add 2.1 DD. including 1.-2. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

16. Add 3.4 E. including 1.-3. for contracts where sanitary systems work is performed within the jurisdiction of WASA.

17. Add 3.11 E. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

18. Specify the type of cement to be used. The type of cement will vary depending on the jurisdiction and the use of the sanitary system.

19. Specify the type of mortar and cement to be used. They will vary depending on the jurisdiction and the use of the sanitary system.

20. Add 3.15 G. for contracts where work is performed within the jurisdiction of WSSC.

21. Add 3.21 D. including 1.-5. for contracts where work is performed within the jurisdiction of WSSC.

22. Add 3.22 including A.-E. for contracts where work is performed within the jurisdiction of WSSC.

END OF SECTION

SECTION 02585

UNDERGROUND ELECTRICAL AND COMMUNICATIONS DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

This section specifies providing new ducts, manholes and handholes for electrical and communications facilities.

A. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Support of excavation: Section 02260.
3. Maintenance, support and restoration of utility facilities: Section 02270.
4. Grounding and bonding: Section 16060.
5. Concrete formwork: Section 03100.
6. Concrete reinforcement: Section 03200.
7. Cast-in-place structural concrete: Section 03300.
8. Structural precast concrete: Section 03400.

B. Definitions:
1. Conduit: Individual raceway.
2. Ductbank: Assembly of conduits in configurations shown, with concrete encasement, with or without reinforcement.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Drawings for each cast-in-place manhole and handhole.
   b. Drawings for each size and configuration of precast manhole and handhole with details of accessories and joints.
   c. Diagrams showing dimensioned locations for openings and knockout panels for ductbank penetrations of manhole and handhole walls.
2. Documentation:
   a. Submit calculations to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: H15-44, H20-44.
3. ANSI: C80.1.
4. ASTM: A36, A48, A123, A185, A615, C33, C109, C173, C231, D570, D638, D790, F512.
5. NEMA: TC-14.
6. UL: 6.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Transport those materials supplied by utility companies from companies' storage facilities to construction site.

B. Protect materials stored on site from damage prior to incorporation into work and during handling.

1.05 JOB CONDITIONS:

A. Coordination with Utility Companies:
1. Arrange with the Engineer to contact utility companies early enough to allow sufficient time for them to accomplish work they are required to perform, giving special consideration to lead times required for cable work.
2. Establish liaison with utility companies furnishing materials for the work in order to determine availability, locations, methods of storage and care of materials prior to incorporation into work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Concrete Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Concrete:
1. Cast-in-place: Section 03300, Class 3500 or as required by the power company for its facilities.
2. Precast: Section 03400, Class 5000, unless otherwise shown on the drawings.

D. Materials Supplied by Utility Company: As listed.

E. Conduit and Fittings:
1. PVC conduit and fittings: ASTM F512; modulus of elasticity, 500,000 psi.
2. Concrete encased: Schedule 40.
   a. Direct burial: Schedule 80 heavy wall.
   b. Solvent cement: As recommended by conduit manufacturer.
3. Galvanized rigid steel conduit and fittings: UL 6 and ANSI C80.1.
4. Fiberglass conduit and fittings:
   a. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
   b. Rigid fiberglass-reinforced epoxy, filament wound with minimum fiberglass content of 65 percent by weight and no fillers.
   c. Type SW (Standard Wall) of IPS based standard conduit with nominal wall thickness of .09 inch for five-inch nominal conduit size, and nominal wall thickness of 0.07 inch for two through four-inch nominal conduit size.
   d. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
   e. Conduit sections formed with integral bell-and-spigot type couplings. Rubber sealing gasket at bell end is prohibited.
   f. Conduits, elbows and fittings shall be specified for use throughout a temperature range of -40°F to 230°F and protected from exposure to sunlight by pigmentation uniformly dispersed through resin material.
   g. Adhesive as recommended by conduit manufacturer.
   h. Conduit, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL, meeting

the requirement of NEC Article 347 for Rigid Nonmetallic Conduit and its use.

i. Conduit for above ground surface mounted duct systems shall pass the UL1684 mandatory flame test (UL 1684, Section 5.12.1) and be certified by the manufacturer as such.

j. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, marked clearly legible and durably every 10 feet or as recommended by the manufacturer:
   a. "Reinforced Thermosetting Resin Conduit", "RTRC", or equivalent wording such as "FRE" (Fiberglass Reinforced Epoxy) conduit.
   b. Nominal size: (IPS)
   c. Manufacturer's name and trademark.
   d. Temperature range for conduit application.
   e. "Above ground", "AG", "Below ground", "BG", or equivalent wording.
   f. "FT4" when flame test is required for above ground conduit.

5. Conduit seal fittings:
   a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
   b. Size as shown or necessary.
   c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of PVC or galvanized steel.
   d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

F. Channel Inserts: Stainless steel, size and shape as shown, 12-gauge minimum thickness, with 7/8-inch slot; surface-mounted; slotted-base channel with 9/16-inch by 3/16-inch nominal mounting slots on eight-inch centers.

G. Cable Pulling Eye: Fabricated of plain steel reinforcement bar, ASTM A615, Grade 60; welded; size as shown. Hot-dip galvanized after fabrication, ASTM A123. Pulling tension: 5,000 pounds.

H. Manhole Frame and Cover:
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
3. Rust-resistant cast iron or rust-resistant malleable cast iron.
4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
5. Fillets at angles in casting with arises sharp and perfect.
6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
7. Covers to receive paver tile:
   a. Omit bituminous coating.
   b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.

I. Manhole Steps:
1. ASTM A48, cast-iron, Class 30A.
2. Molded rubber or plastic on cast-iron or reinforcing steel core.

J. Handhole and Manhole: Option of cast-in-place or precast.
1. Cast-in-place concrete handhole and manhole: As shown and specified.
2. Precast concrete:

a. Shape shown. If precast manholes are selected and size shown is not standard, use nearest larger standard precast unit; where added size will conflict with other utilities or structures, use cast-in-place unit.
b. Designed for AASHTO H20-44 truck loading.
c. Manhole: Include lifting rings, manhole steps, pulling eyes, sump, hole through floor for ground rod, and seal or sealant for sealing joints between sections, precast extensions included where required by utility.

3. Precast concrete handhole: Compressive strength 3,500 psi, air entrainment six-percent minimum, ASTM C173 or ASTM C231; Section 03300 and Section 03400 and in accordance with the following:
   a. Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown on the drawings..
   b. Cover:
      a. Material same as for box. Use of metallic cover and cover frame prohibited.
      b. Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
      c. Non-protruding provisions provided for lifting.
   c. Reinforcement:
      a. Sidewalk and landscape locations: Welded-wire fabric, ASTM A185.
      b. Areas subject to vehicular traffic: Deformed steel bars, ASTM A615.
   d. Loading:
      a. Sidewalk and landscape locations: AASHTO H15-44.
      b. Areas subject to vehicular traffic: AASHTO H20-44.
   e. Hardware: Stainless steel.
   f. Size: As shown or next available larger size.

K. Precast composite material handhole: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Methods
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water absorption (24 hours)	0.5 percent	ASTM D570

1. Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.
2. Cover:
   a. Material same as for box.
   b. Skid-resistant top surface with minimum 0.5 coefficient of friction.
   c. Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
   d. Secured to box with bolts.
   e. Non-protruding provisions provided for lifting.
   f. Loading:
   g. Sidewalk and landscape locations: AASHTO H15-44.
   h. Areas subject to vehicular traffic: AASHTO H20-44.

i. Hardware: Stainless steel.
j. Size: As shown or next available larger size.

L. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate No. 4 and No. 67.

M. Spacer: As shown or recommended by conduit manufacturer.

N. End Bells: Flared, smooth-surfaced fittings of same material as conduit; if of different material, include adaptor for connection to conduit.

O. Grounding: Section 16060.

P. Brick: Section 04215.

Q. Mortar: Section 04050.

PART 3 - EXECUTION

3.01 EXCAVATING AND BACKFILLING:

A. Excavating and backfilling: In accordance with Section 02320.

B. If ducts and manholes are to be installed on backfill over subway structure, place and compact backfill up to grade shown for ductbanks, conduits, manholes and handholes; compact as specified in Section 02320; ensure the manhole sets level. Schedule completion of backfilling to allow sufficient time for installation of ductbanks, conduits, manholes and handholes.

C. Where shown for subgrade foundation, use layers of coarse aggregate No. 4 and No. 67 in combinations and proportions determined by field conditions.

3.02 PAVEMENTS, SIDEWALKS, CURBS AND GUTTERS:

A. Remove pavements, sidewalks, curbs and gutters where necessitated by construction of ductbanks, manholes and handholes in accordance with Section 02220.

B. Place temporary bituminous pavement in accordance with Section 02740, when necessary because of sequence of operations.

C. On completion of construction, replace pavements, sidewalks, curbs and gutters in accordance with Section 02205.

3.03 INSTALLATION:

A. General:
1. Use size, type, general routing and locations of ductbanks, conduits, manholes and handholes as shown and specified.

B. Ductbanks:
1. Place conduits in ductbanks on spacers or construct concrete base prior to placing bottom row of conduits.
2. Use spacers to provide conduit spacing and support as recommended by conduit manufacturer.
3. Make conduit joints watertight by complying with recommendations of conduit manufacturers and as follows:

a. PVC conduit: Use solvent cement to join conduits, elbows and fittings.
b. Galvanized steel rigid conduit: Use lead-free conductive anti-seize compound on threaded conduit joints.
c. Fiberglass conduit: Use adhesive to join conduits, elbows and fittings for water tightness and pull out strength. Follow instructions of conduit manufacturer for using adhesive during periods below the recommended temperature range. Use of rubber sealing gaskets and interference type joints is prohibited.

4. Use Schedule 40 PVC conduit for underground ductbanks except as follows:
   a. Use galvanized steel rigid conduit only in specific locations as shown.
   b. Use fiberglass conduit only for providing utility company's 13.8 kv electric services.
5. Place and compact concrete around conduits in accordance with Section 03300.
6. Where shown, install reinforcing steel in concrete encasement in accordance with Section 03200.
7. Bends:
   a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
   b. Install bends in buried conduit in accordance with the following:

Size of conduit in inches	Minimum radius of factory-bend in inches	Minimum radius of field-bend in inches
3	18	24
4	24	30
5	48	48
6	48	48

   c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.
   d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
   e. Field-made bends in fiberglass conduits are prohibited.
8. Support conduit during construction using compatible conduit supports and spacers to maintain positions of conduit during placement of concrete and to ensure independent support.
9. Install conduit so that it drains to adjacent manhole or handhole.
10. Prevent concrete and other foreign materials from entering, obstructing or deflecting conduit. Cap or plug conduit ends prior to pouring concrete.
11. Remove burrs from conduit ends, clean and dry before applying solvent cement to PVC conduit joints or adhesive to fiberglass conduit joints.
12. Pull approved test mandrel and swab through each conduit after installation. Cap or plug conduit ends. If mandrel cannot be pulled through conduit, replace conduit.
13. Leave approved nylon or polyester pull-line in each conduit.
14. At the ends of each conduit, use corrosion-resistant metallic tags with stamped markings to establish identification in accordance with designations shown. Install tags securely to permanent structure near each conduit as approved by the Engineer.
15. Install caps at empty conduit ends for future use.

C. Conduits Without Concrete Encasement:
1. Use Schedule 80 for direct-buried train control conduit.

2. Install caps on ends of empty train control conduits and identify locations of conduit ends with stakes.

3.04 CONSTRUCTION OF MANHOLES AND HANDHOLES:

A. Provide drainage facilities for manholes and handholes where shown. If connection is made to existing sewer line, install connection in accordance with applicable local regulations

B. Erect formwork in accordance with Section 03100.

C. Place reinforcing in accordance with approved shop drawings.

D. Provide for location of ductbank entrances and inserts in walls as shown.

E. Place concrete as specified in Section 03300.

F. Install conduits of material shown.

G. Install end bells on conduits where ductbanks terminate in manholes and handholes.

H. Build ductbank formation into walls of manholes and handholes and seal around opening.

I. If location of manholes and handholes openings will be obstructed, so inform the Engineer.

J. Install frame and cover, adjusting to finished grade, building brick chimney as specified in Section 02535.

K. Seal conduit openings with approved conduit plugs.

L. Install cable pulling eyes and steps as shown. Test pulling eye for compliance with specified pullout load rating.

M. Install ground rods, 2-inch by 1/4-inch by 12-inch long ground bus bar and insulated grounding conductors where shown. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved. Provide grounding for personnel protection as specified in Section 16060.

N. When installing sections of precast manholes and handholes, prevent damage to joints seals.

O. Provide full-height stainless steel channel inserts approximately two feet on center along interior walls, spaced to clear ductbank entrances and steps. Use expansion bolt anchors to secure channel inserts to walls. Install and test channel inserts in accordance with Section 16130.

3.05 INSTALLATION OF HANDHOLES:

A. Bury precast concrete or composite material handholes with cover mounted flush with finish grade or pavement. Comply with installation procedures furnished by manufacturer.

3.06 CLEAN UP:

A. Remove debris from manholes and handholes and ensure complete installation is left in neat and finished condition.

3.07 FIELD QUALITY CONTROL:

A. Arrange with the Engineer for inspection and approval of conduits in ductbank and cast-in-place manholes and handholes prior to concrete placement.

B. Arrange with the Engineer for a representative of the utility company to inspect and approve service conduits for Authority facilities, relocated utility conduits, manholes and handholes prior to concrete placement.

C. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits, prior to backfilling.

END OF SECTION

SECTION 02635

STORM SEWER

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies installing storm sewers, roadway drains, roadway underdrains, ditch lining and slope protection.

B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Maintenance, support and restoration of utility facilities: Section 02270.
3. Stray current and cathodic protection: Section 13110 and 13115.

C. Material Furnished By Others: *1
1. Except for those items which bear the METRO logo, WSSC furnishes the following:
   a. Manhole frames and covers: 22-inch diameter.
   b. Manhole steps, except where precast manholes are used.

D. Definitions: *2
1. Granular bedding required by WSSC is equivalent to aggregate for pipe cradle as specified.
2. WSSC: Washington Suburban Sanitary Commission.
3. WASA: Water and Sewer Authority.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Drawings for each size and configuration of precast manhole with details of accessories and joints.
   b. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.
2. Documentation:
   a. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.
3. Samples:
   a. Sewer brick: Ten.
   b. Manhole brick: Ten.
   c. Slope protection materials:
      1) Concrete blocks: Ten each.
      2) Paving bricks: Ten each.
      3) Riprap: 1.5 cubic yards.
      4) Gabions: Two each, complete.
   d. Geotextile filter fabric: Two, 12 inches long by 12 inches wide, minimum.

4. Certification.
5. Documentation: *3
   a. Submit two copies of records of inspection of new and relocated sewers, one copy to W\SSC and one copy to the Engineer. Include video-tape

cassette of television inspections and logs, photographs and other records specified by WASA for visual walk-through inspections.

b. Obtain and submit a written approval and acceptance from WASA.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. Building Stone Institute: Stone Catalog.
3. CISPI: HSN 85.
4. AASHTO: M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. *4
5. AASHTO: H20, M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. *5
6. ANSI/ASME: B16.1. *6
7. ACI: 318. *7
8. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C507, C700, D698, D1682, D3034, D5034, D5035. *8
9. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D1682, D3034, D5034. D5035. *9
10. MS: MIL-P-23236.
11. SSPC: SP-6.
12. WSSC: General Conditions and Standard Specifications. *10

B. Source Quality Control:
1. Ditch lining and slope protection materials:
   a. After approval, do not change source.
   b. Replace defective material.

C. Allowable Tolerances:
1. Subgrade: Plus-or-minus 1/2 inch of elevation shown.

D. Inspection: *11
1. Prior to paving or other construction over new or relocated sewers, conduct visual walk-through inspection of sewers larger than 36 inches in diameter and of associated structures and internal television inspection of sewers 36 inches and smaller in diameter.
2. Employ the services of a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to WASA to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter.
   a. Submit to WASA for prior approval one sample of the cassettes to be used.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Portland Cement Concrete: Section 03300, Class 3500, unless otherwise shown.

D. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4. Where shown use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.

E. Aggregate for Pipe Cradle: ASTM C33, coarse aggregate No. 67.

F. Concrete Pipe:
1. 10-inch diameter and smaller:
   a. ASTM C14, Class 2, nonreinforced concrete pipe.
   b. Bell-and-spigot type.
   c. Joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
2. 12-inch diameter and larger:
   a. ASTM C76, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
   b. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
   c. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
   d. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
      1) 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
      2) Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.
   e. Minimum laying lengths: Four feet.
   f. Rubber gaskets: ASTM C361. *12
   g. Rubber gaskets: ASTM C443. *13
   h. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
      1) When applied to a vertical metal surface and heated to 120F, jointing mastic will neither slump nor lose plasticity.
      2) When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20F to 100F.
   i. Reinforced concrete elliptical pipe: ASTM C507. *14
3. Perforated nonreinforced concrete pipe: AASHTO M175, Type 1 or 2, bell-and-spigot or tongue-and-groove type.
4. Porous concrete pipe: AASHTO M176, tongue-and-groove.

G. Plastic Pipe:
1. Polyvinyl chloride (PVC) pipe: ASTM D3034, SDR-35.
2. Polyethylene corrugated pipe: AASHTO M252.

H. Bituminous-Coated Corrugated Metal Pipe: AASHTO M190, Type A or C, with connecting bands, AASHTO M36.

I. Vitrified Clay Pipe: ASTM C700; Joints, ASTM C425, using plastic materials.

J. Cast-Iron Soil Pipe and Fittings: ASTM A74, extra-heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets conforming to CISPI Designation HSN 85 and the requirements of the relevant plumbing codes.

K. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.

L. Mortar Materials:

1. Portland cement: ASTM C150, Type I.
2. Sand: ASTM C144, natural sand.
3. Lime: Pressure-hydrated, ASTM C207, Type S.
4. Water: Potable.
5. Pigment: As approved.

M. Brick: ASTM C32; solid brick; Grade MS for manhole brick, Grade SS for sewer brick; 2-1/4 inches by 3-3/4 inches by eight inches.

N. Precast Concrete Manhole Sections: *15
1. ASTM C478.
2. Joint entry seal gasket: A-LOK as manufactured by Atlantic Precast Concrete, Inc.; A-LOCK gaskets, manufactured by A-LOK Products Corporation, Trenton, N.J.; DURAC-SEAL gaskets, manufactured by DURA-CRETE, Inc., Dayton, Ohio; or equal.

O. Precast Concrete Manholes: *16
1. Cylindrical, eccentrical and conical: ASTM C478.
2. Other configurations: ACI 318, AASHTO H20.

P. Manhole Steps:
1. Cast iron: ASTM A48 Class 30 A.
2. Rebar: No. 4 reinforcing bar with molded polypropelene or rubber encasement.

Q. Manhole Frame and Cover; Inlet Frame and Grate; and Ballast Screen;
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
2. *Rust-resistant cast iron or rust-resistant malleable cast iron.*
3. *True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.*
4. *Fillets at angles in casting with arises sharp and perfect.*
5. *Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.*
6. *Covers that receive paver tile:*
   a. *Omit bituminous coating.*
   b. *Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.*

R. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or equal.

S. Structural Steel Members: ASTM A36.

T. Steel Pipe: ASTM A53, black finish, extra strong wall class.

U. Stainless Steel Angle: ASTM A167, Type 304.

V. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.

W. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.

X. Bituminous Expansion Joint Filler: AASHTO M33.

Y. Galvanizing: Section 05120.

Z. Ditch Lining and Slope Protection:
1. Riprap: Material meeting the following requirements:

a. Hard, durable and free of fractures; angular in shape; weather-resistant; and free from overburden, spoil, shale and organic material.
b. Size: Weight distribution of pieces provided in accordance with the following:
1) Class I: From 50 to 150 pounds with 60-percent minimum weighing 100 pounds or more; approximately 10 percent may weigh 50 pounds or less.
2) Class II: From 150 to 500 pounds with 50-percent minimum weighing more than 300 pounds; approximately 10 percent may weigh 150 pounds or less.
c. Quality:
1) Water absorption: 3.0-percent maximum when tested in accordance with AASHTO T85.
2) Specific gravity: 2.5 minimum when tested in accordance with AASHTO T85.
3) Resistance to abrasion: Grade B maximum when tested in accordance with AASHTO T96.
4) Soundness: Loss 20-percent maximum when tested in accordance with AASHTO T104.

2. Aggregate filter:
a. Coarse aggregate, ASTM C33, Size 357.
b. Use only tough, durable materials free of thin, flat, elongated or soft friable particles and free of organic matter.
3. Granite block facing: Type 4, quarry split finish on face and edges.
4. Sand cushion for concrete block: Section 03300, fine aggregate.

AA. Geotextile Filter Fabric: AASHTO M288 and the following additional requirements:
1. Woven or non-woven pervious filter fabric weighing approximately 0.03 to 0.05 pounds per square foot; free of defects.
2. Fabric: Long chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, amide or vinyl-chloride and with stabilizers or inhibitors to make fabric resistant to deterioration due to ultraviolet and heat exposure.
3. Fabric formed or treated so that filaments retain their positions relative to each other.
4. Edges selvaged.
5. Physical strength:
a. Tensile strength: 200-pound minimum in each direction, ASTM D1682.
b. Elongation at failure: 10 to 30 percent, ASTM D5034 amd D5035.
c. Puncture strength: 70-pound minimum, ASTM D5034 and D5035.
6. Percent of open area: Not less than five percent nor more than six percent.
7. Equivalent opening size (E.O.S.): 70-100 US Standard Sieve, CW-02215-77.
8. Securing Pins: As recommended by manufacturer of filter fabric.

BB. Gabions:
1. Wire mesh: Galvanized steel wire 0.105 minimum diameter, 60,000 pounds per square inch tensile strength, galvanized at rate of 0.80 ounces per square foot. Wires twisted to form nonraveling hexagonal openings of uniform size, not to exceed 4-1/2 inches in length nor eight square inches in area of mesh opening. Horizontal dimension uniform, not to exceed 36 inches. Gabion dimensions not to vary more than three percent from manufacturer's stated size.
2. Tie devices: Malleable iron or steel, producing frictional force of 160 pounds per foot of spacing. Sized to conform to requirements of jurisdictional agency.
3. Stone: Durable, free from cracks and seams, unweathered, weighing between four pounds (four-inch average diameter) and 30 pounds (eight-inch average diameter) except five percent may vary more or less and 50 percent to exceed 10 pounds.
a. Stone size:

Basket Thickness (Inches)	Size of Stones (Inches)
6	3 to 5
9, 12, 18	4 to 7
36	4 to 12

CC. Coal-Tar Epoxy Coating:
1. Two-component.
2. Chemically cured.
3. Conforming to MS MIL-P-23236 (Ships), Type I, Class 2.
4. Thinner: As recommended by manufacturer of coating and as approved.

DD. Pipe Supports: *17
1. Pipe: Three-inch diameter, ASTM A53, Weight B, Class 1.
2. Flanges: ANSI/ASME B16.1, 125-pound Class, galvanized after fabrication.

EE. Underdrain Filter Material: ASTM C33, Size 57. *18

2.02 MORTAR AND GROUT MIXES:

A. General Requirements:
1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
2. Add sufficient water as specified to produce approved consistency.
3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
4. Do not retemper mix that has begun to set nor use such mix in the work.
5. Where shown, specified or directed, mix pigment into dry mix to attain color selected by the Engineer. Pigment not to exceed 10 percent of dry batch weight of cement.

B. Proportions:
1. Mortar: One part portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
2. Grout: One part portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.
3. Mortar for setting and pointing granite: One part portland cement, four to five parts sand, one part lime and water sufficient to produce approved consistency.
4. Mortar for setting granite paving and grouted granite blocks: One part portland cement, four parts sand, with water sufficient to produce approved consistency.

PART 3 - EXECUTION

3.01 EXCAVATION FOR SEWER AND DRAINAGE STRUCTURES:

A. Perform excavation for sewers and drainage structures to line and grade shown in accordance with Section 02320 and the following additional requirements:
1. Excavate test pits sufficiently in advance of construction of sewers and drainage structures so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.
2. Excavate below horizontal plane extending two feet above top of sewer or drainage structures to maximum width of trench pay width shown. Where dimensions are not shown, make maximum horizontal width of excavation 18 inches from outside of

sewer or drainage structure and minimum six inches. Where approved, excavation above such plane may exceed specified dimensions.

3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength.
4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

3.02 GEOTEXTILE FILTER FABRIC:

A. Prepare surface to receive fabric to relatively smooth condition free of obstructions, depressions, debris and soft or low density pockets of material.
   1. Place fabric with long dimension parallel to centerline of trench and lay smooth and free of tension, stress, folds, wrinkles or creases with sufficient excess to allow for minimum overlap of 12 inches.
   2. Place strips in trench to provide minimum width of 12 inches of overlap for each joint.
   3. Insert securing pins with washers through both strips of overlapped fabric at not greater than 3-foot intervals along a line through the midpoint of overlap at joints.
   4. Where this method of placement conflicts with manufacturer's instructions, the manufacturer's instructions prevail.

B. At time of installation fabric to be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation, storage or handling.

C. Place fabric in manner and at location shown.

3.03 PIPE CRADLE:

A. Place pipes on cradle of aggregate or concrete where shown.

B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

3.04 LAYING PIPE:

A. General Requirements:
   1. Excavate to lines and grades shown in accordance with Sections 02320 and herein. Excavate depressions for bells.
   2. Protect pipe and fittings during handling to prevent damage.
   3. Place, shape and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.
   4. Start laying pipe at lowest point; lay true to line and grade shown.
   5. Install pipe to bear on bedding material along entire length. Shape bedding material to fit bells and flanges.
   6. Install perforated pipe with perforations downward.
   7. Install pipe so that bells and grooves are on upstream end.
   8. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.
   9. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.
   10. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.
   11. Keep trenches and excavations free of water during construction and until backfilled. Each day, excavate only as much trench as needed to lay pipe.

12. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.
13. Where length of stub is not shown, install four-foot length and seal free end with brick masonry bulkhead or approved stopper.
14. Have work approved prior to covering pipe.
15. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding six inches loose. Compact each lift before placement of next lift.
16. Backfill in accordance with Section 02320.
17. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached three feet or half the pipe diameter, whichever is greater.
18. Where cathodic protection is shown, apply coal-tar epoxy coating.

B. Vitrified Clay Pipe:
1. Nonperforated pipe:
   a. Use pipe hoist, crane or other approved device when laying pipe greater than 18 inches diameter.
   b. Prevent damage to premolded joint rings or attached couplings.
   c. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers or adhesives as recommended by pipe or joint manufacturer
2. Perforated pipe:
   a. Firmly position spigot in bell of preceding pipe. Saturate jute gasket in cement grout and caulk into annular space. Ensure that jute is long enough to reach entirely around pipe and is of such thickness to bring pipe sections to same grade.
   b. After pipe sections have been caulked and centered, fill annual space with cement mortar.
   c. After mortar joints have set, place additional aggregate filter material as specified.

C. Concrete Pipe:
1. Bell-and-spigot joints:
   a. Lay bell-and-spigot joint pipe as specified for vitrified clay pipe.
2. Tongue-and-groove joints:
   a. Clean groove end of preceding pipe with wet brush and apply soft mortar to lower 1/4 of groove. Clean tongue end of succeeding pipe with wet brush and position it. Remove mortar from interior surface if squeezed out of joint.
   b. Complete mortaring interior and exterior portions of joint for entire circumference, extending from previously placed mortar. Perform final exterior mortaring of joints three lengths of pipe behind laying.

D. Plastic Pipe:
1. Perforated pipe:
   a. Use sleeve couplings designed to hold pipe in alignment without use of sealing compound or gaskets.
   b. Place additional aggregate filter material as specified.
   c. Cap open ends of underdrains.
2. Nonperforated pipe:
   a. Join sections of pipe with couplings recommended by pipe manufacturer.

E. Corrugated Metal Pipe:
1. Perforated pipe:
   a. Place additional aggregate filter material as specified
2. Nonperforated pipe:

a. When pipe is shown to be bituminous paved, place paved area on bottom.

3. Connections for corrugated metal pipe:
   a. Join sections of pipe with coupling bands arranged to fit corrugations accurately.
   b. Do not damage protective coating when tightening bolts.
   c. After final tightening of connection bolts, apply brush coat of bituminous paint to bands and bolts.

F. Porous Concrete Pipe:
1. Fill joints with mortar as specified for tongue-and-groove joints of concrete pipe.
2. After pipe joints have been made, place additional filter material as specified.

G. Inspections Of Sewers: *19
1. Perform all work in accordance with current requirements of WASA.
2. Perform inspections on new or relocated storm sewers within or adjacent to the zone of influence, as defined by the limits of a theoretical slope of 1:1 from the bottom edges of tunneling and cut-and-cover excavations, as follows:
   a. Make inspections upon completion of tunneling and cut-and-cover operations, but prior to paving.
   b. Obtain video-tape television inspection records of sewers 36 inches and smaller in diameter.
   c. By means of visual walk-through inspection, obtain coordinated logs, photographs and other records specified by WASA of sewers larger than 36 inches in diameter and of associated structures.
3. Coordinate all television and walk-through inspection field operations with WASA. All such work to be performed in the presence of a WASA representative.

3.05 BACKFILL:

A. Perform backfilling only after inspection and approval of pipe laying.

B. On completion of construction, backfill excavation in accordance with Section 02320.

3.06 JOINTS FOR CONCRETE STORM SEWER: *20

A. Use cold-applied jointing mastic for joints of storm sewer.

B. Bell-and-Spigot Joints:
1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
3. Apply sufficient jointing mastic to fill remaining void in joint.
4. Remove excess mastic from interior of pipe.

C. Tongue-and-Groove Joints:
1. Clean groove. Apply mastic to lower half of groove.
2. Clean tongue of next pipe and apply layer of mastic to upper half.
3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.
4. Remove excess mastic from interior of pipe.

3.06 JOINTS FOR CONCRETE STORM SEWER 12 INCHES TO 33 INCHES: *21

A. Use cold applied jointing mastic for joints of storm sewer 12 inches to 33 inches in diameter.

B. Bell-and-Spigot Joints:
   1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
   2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
   3. Apply sufficient jointing mastic to fill remaining void in joint.
   4. Remove excess mastic from interior of pipe.

C. Tongue-and-Groove Joints:
   1. Clean groove. Apply mastic to lower half of groove.
   2. Clean tongue of next pipe and apply layer of mastic to upper half.
   3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.
   4. Remove excess mastic from interior of pipe.

3.06 JOINTS FOR CONCRETE STORM SEWER 36 INCHES AND LARGER. [*22]

A. Where not prohibited by jurisdictional agencies, Use mortar for joints of storm sewers 36 inches diameter and larger.

B. Bell-and-Spigot Joints:
   1. Where pipe cradle is aggregate, place shallow bed of mortar under joint.
   2. Thoroughly wet bell and fill lower half with mortar.
   3. Thoroughly wet spigot and uniformly fit into bell so that sections are closely fitted and aligned.
   4. Fill remaining annular space in bell with mortar sufficient to form bead around outside of spigot end of pipe.
   5. Remove excess mortar from interior of pipe and finish exterior and interior to smooth surfaces.

C. Tongue-and-Groove Joints:
   1. Thoroughly wet groove; apply mortar to lower half of groove.
   2. Thoroughly wet tongue of next pipe and apply a layer of mortar to top half.
   3. Fit tongue into groove until pipes are closely fitted and aligned and mortar covers inner and outer surfaces of the joint.
   4. Clean inner surface of pipes at joint and point up outside with bead of mortar.

3.07 JOINTS FOR VITRIFIED CLAY PIPE:

A. Immediately before joining vitrified pipe, liberally coat bell with lubricant and fit spigot with gasket.

B. Join pipes using equipment designed for purpose.

3.08 JOINTS FOR CAST-IRON SOIL PIPE AND FITTINGS:

A. Immediately before joining cast-iron soil pipe and fittings, liberally coat hub with lubricant and fit spigot with pipes using equipment designed for purpose.

3.09 CONNECTIONS WITH EXISTING SEWERS:

A. Make connections with existing public sewers in accordance with requirements of the jurisdictional authority.

B. Do not connect existing sewer to sewer under construction unless approved.

3.10 TUNNELING AND JACKING:

A. Perform tunneling and jacking by approved methods.

B. Where open cut is specified and the Engineer permits the work to be done by tunneling or jacking, perform such work as specified and as approved.

C. Cost of material substitutions required by change of methods will be borne by the Contractor.

D. Make horizontal borings necessary to lay pipe lines true to line and grade.

E. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.

F. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.

G. Methods of boring and filling of voids between pipe and boring are subject to approval.

3.11 CAST-IN-PLACE CONCRETE CONSTRUCTION:

A. Conform to applicable requirements of Sections 03100, 03200 and 03300. Section designer to specify the type of cement to be used. The type of cement will vary depending upon the jurisdiction where the work is performed.
   1. Cement. *23

B. Construct concrete support systems where shown. Section designer to specify the type of mortar to be used. Mortar type will vary depending upon jurisdiction in which the work is performed.
   1. Mortar and cement. *24

3.12 BRICK CONSTRUCTION:

A. Perform brick construction as specified in Section 04215, with the following additional requirements:
   1. Use sewer brick wherever brick construction is exposed to flow; otherwise, use manhole brick.
   2. Lay sewer brick on edge so that 2-1/4 by 8-inch side is exposed to flow.
   3. Lay manhole brick so that every sixth course is a header course.
   4. Where practicable, lay each course with a line. For curved courses or those in nonparallel planes, use bonded-and-keyed construction.
   5. Do not exceed joint thickness of 3/8 inch in straight courses in parallel planes; for courses curved or in nonparallel planes, make thickest part of joint as thin as practicable.
   6. Rack or tooth uncompleted brick construction and parge unexposed surfaces with 1/2 inch of mortar.

3.13 MANHOLES:

A. Construct manholes of precast sections, cast-in-place concrete or brick as shown.

B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.

C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.

D. Construct appropriate flow channels in bottom of manholes.

E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.

F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.

G. Install joint entry seal gaskets in openings in the walls of 48-inch precast manholes with O-ring joint. *25

3.14 CATCH BASINS AND INLETS:

A. When grading has been substantially completed as approved, construct catch basins of cast-in-place concrete using Class 3500 concrete and steel reinforcement as shown, precast sections or brick as shown.

B. Cut pipe flush with inside wall of structure. Provide mortar joint between pipe and structure or install water seal as shown.

C. Install cast iron frame and grate or cover and adjust to proper grade.

D. Install pipe supports as shown. Fill with concrete after installation. *26

3.15 DITCH LINING AND SLOPE PROTECTION:

A. Slope Preparation:
1. Excavate or fill slopes to the required cross section, lines and grades.
2. Compact earth slopes to not less than 95 percent of the maximum dry density for a depth of not less than 12 inches, as specified in Section 02725.
3. Where lining or protection is to be applied to rock surfaces, clean off mud, debris and loose fragments.
4. Construct toe or cut off walls where shown.
5. Remove loose material and buried debris protruding from subgrade.
6. Placement of aggregate filter:
   a. Place filter aggregate where shown to depth shown.
   b. Compact each layer of aggregate filter in accordance with ASTM D698, Method D, to 100 percent at plus-or-minus one percent of optimum moisture content.

B. Ungrouted Riprap:
1. Place aggregate filter as specified.
2. Place riprap by machine to full course thickness in one operation upward from bottom of slope. Prevent displacement of underlying materials. Dumping of riprap is prohibited.
3. Fill spaces between larger stones to produce nearly even surface with minimum of voids. Manually supplement machine placement of stone to choke in voids.
4. Rearrange individual stones as necessary to ensure that finished configuration conforms to lines, grades and thickness shown.

C. Bituminous Concrete Paving:

1. Place bituminous concrete where shown to the lines, grades, thickness and shapes shown.
2. Give base course prime coat of medium-curing, cutback asphalt and allow to cure before hot bituminous concrete is placed.
3. Place hot-mix bituminous concrete by hand or by machine.
4. When hand methods are used, place mixture by means of hot shovels or forks and spread with hot rakes to thickness required to obtain specified compacted thickness. Thoroughly rake loose material throughout its depth, to eliminate honeycombing. Use screed boards of width equal to required thickness of lining.
5. After spreading, compact until specified compacted thickness is obtained.
6. Place mixture as continuously as practicable to eliminate joints. Where joints are required at end of a day's work or when the placing is discontinued for such period of time that material becomes chilled, form joints as specified.

D. Cast-in-Place Concrete:
1. Use Class 3500 concrete unless otherwise shown.
2. Use wood or steel forms.
3. Place reinforcing steel or wire mesh as shown.
4. Provide and install dowel bars where shown in accordance with Section 02750.
5. Locate expansion and contraction joints where shown in accordance with Section 02750.
6. Unless otherwise shown, give surface wood float finish.
7. Protect and cure concrete in accordance with Section 03300.

E. Concrete Masonry Units:
1. Place two-inch layer of sand cushion on previously prepared slope.
2. Set units firmly by hand in sand cushion with long dimension parallel to base of slope so as to produce even surface.
3. Lay blocks with open 3/8-inch joints and with joints staggered as shown.
4. Completely fill joints with mortar.
5. Protect and cure newly laid blocks for seven days using wet cotton mats or wet burlap.
6. Lay blocks when the temperature is 40F or above.

F. Paving Brick:
1. On the previously prepared slope, place concrete base of thickness shown.
2. Give concrete smooth screed finish.
3. Clean base, dampen and lay one-inch thick mortar bed.
4. Lay bricks with long dimension parallel to base of slope, with open 3/8-inch joints and with joints staggered.
5. Bed bricks firmly in mortar bed so as to produce even surface free from depressions or high spots.
6. Fill joints completely with mortar.
7. Protect and cure newly laid brick for a period of seven days using wet cotton mats or wet burlap.

G. Sodding: Section 02920.

H. Concrete Pavement:
1. Lay plastic pipe as shown.
2. Place aggregate filter as specified.
3. Place concrete base in accordance with specified requirements for cast-in-place concrete.

I. Concrete with Granite Block Facing:
1. Lay plastic pipe as shown.

2. Place aggregate filter as specified.
3. Place concrete base in accordance with specified requirements for cast-in-place portland cement concrete.
4. Installation of granite block facing:
   a. et granite blocks in bedding course, one-inch minimum depth with 3/4-inch joint width.
   b. Slope bedding to true surface parallel to finished surface of blocks; strike off bedding until true alignment is attained.
   c. After final sloping, do not disturb bedding prior to laying blocks.
   d. Lay blocks on bedding course in successive courses with quarry split finish up.
   e. Align each course, lay true and even and bring to true grade by use of wood mallets or similar tools.
   f. Lay blocks in continuous sequence.
   g. Lay no more mortar than can be covered with blocks before end of work day.
   h. Point voids in joints with preshrunk mortar. Do not point when ambient temperature is 50F and falling.After pointing, scrub surfaces with soap solution and remove stains. Rinse immediately with clean water. Leave work in first class condition, free from mortar stain and other defacement as approved.

J. Gabions:
1. Prepare ground surface smooth and even where gabions will be installed.
2. Assemble gabions and tie together in accordance with manufacturer's instructions.
3. Fill gabions in lifts of 12 inches maximum. Install tie devices in all units with exposed faces, spaced in accordance with requirements of jurisdictional agency.
4. Ensure stone fill is placed without voids larger than approximately smaller stones. Hand-place stones in exposed faces.

3.16 CONCRETE HEADWALLS AND WINGWALLS:

A. Excavation:
1. Excavate for foundations and walls to lines and grades shown in accordance with Section 02320.

B. Formwork and Reinforcement:
1. Erect formwork and install reinforcement as shown and in accordance with Sections 03100 and 03200.

C. Concrete Work:
1. Place concrete of class shown and protect and cure in accordance with Section 03300.

D. Backfilling:
1. Backfill and compact in accordance with Section 02320.

3.17 COATING APPLICATION AND REPAIR:

A. Preparation of surface: Perform the following in order given:
1. Clean surfaces contaminated with oil or grease using naphtha or xylol.
2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP-6.
3. Coat surfaces within 24 hours and before dew point is reached.

4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.
5. Application of coating:
   a. Mix coating in quantity which can be applied within its pot life if in accordance with manufacturer's recommendation. Thin only with approval.
   b. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
      1) Two coats of equal thickness.
      2) Total dry film thickness: 20 mils.
      3) Pretreat first coat as required prior to application of second coat.
      4) Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
      5) Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.
6. Test cathodic protection as specified in Section 13115.

3.18 SUBWAY DRAINAGE SYSTEM: Section 02625.

3.19 FIELD QUALITY CONTROL:

A. Maximum Surface Variation Tolerances:
   1. Grouted riprap: 1-1/4 inches in four feet from true plane.
   2. Bituminous concrete: Plus-or-minus 1/4 inch from specified grade in 25 feet.
   3. Cast-in-place concrete: Plus-or-minus 1/4 inch from specified grade in 15 feet.
   4. Precast concrete block: Plus-or-minus 1/2 inch from specified grade in 25 feet.
   5. Paving brick: Plus-or-minus 1/2 inch from specified grade in 25 feet.

B. Obstruction Tests:
   1. Perform field tests to verify that installed storm systems are free from obstructions.
   2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Engineer.

3.20 TRANSPORTATION AND INSTALLATION OF MATERIALS FURNISHED BY OTHERS: *27

A. Transport and install materials furnished at the WSSC's storeyard at Bladensburg or other delivery points designated by the WSSC.

B. Use only suitable equipment, tools, and appliances for the safe and convenient handling and hauling of materials.

C. Check that all materials furnished by the WSSC are in satisfactory condition.

D. Materials damaged, lost or wasted after acceptance will be replaced by the WSSC at the expense of the Contractor.

E. Material showing inherent defects will be replaced by the WSSC without charge.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Add 1.1 C. including 1.a.-b. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***2**. Add 1.1 D. including 1. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***3**. Add 1.2 E. including 1.-2. for contracts where storm systems work is performed within the jurisdiction of WASA.

***4**. Use first version of 1.3 A.4. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***5**. Use second version of 1.3 A.4. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***6**. Use first version of 1.3 A.5. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***7**. Use second version of 1.3 A.5. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***8**. Use first version of 1.3 A.6. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***9**. Use second version of 1.3 A.6. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***10**. Add 1.3 A.9. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***11**. Add 1.3 D. including 1.-2.a. for contracts where storm systems work is performed within the jurisdiction of WASA.

***12**. Use first version of 2.1 F.2.f. modification for contracts where storm and sanitary systems work is performed within the jurisdiction of WSSC.

***13**. Use second version of 2.1 F.2.f. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***14**. Add 2.1 F.2.h. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***15**. Use first version of 2.1 N. including 1.-2. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***16**. Use second version of 2.1 N. including 1.-2. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***17**. Add 2.1 DD. including 1.-2. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***18**. Add 2.1 EE. for contracts where storm systems work is performed within the jurisdiction of Prince Georges County.

***19**. Add 3.4 G. including 1.-3. for contracts where storm systems work is performed within the jurisdiction of WASA.

***20**. Use first version of 3.6 including A.-C.4. modification for contracts where storm systems work is performed within the jurisdiction of Fairfax County, Virginia.

***21**. Use second version of 3.6 including A.-C.4. for contracts where storm systems work is performed outside the jurisdiction of Fairfax County, Virginia.

***22**. Use second version of 3.7 including A.-C.4. for contracts where storm systems work is performed outside the jurisdiction of Fairfax County, Virginia.

***23**. Specify the type of cement to be used. The type of cement will vary depending on the jurisdiction and the use of the storm system.

***24**. Specify the type of mortar and cement to be used. They will vary depending on the jurisdiction and the use of the storm system.

***25**. Add 3.15 G. for contracts where work is performed within the jurisdiction of WSSC.

***26**. Add 3.16 D. for contracts where work is performed within the jurisdiction of WSSC.

***27**. Add 3.22 including A.-E. for contracts where work is performed within the jurisdiction of WSSC.

END OF SECTION

SECTION 02725
(Version 2)[*1]

BASE FOR PAVEMENTS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing base for pavements as shown, complete in place on previously constructed subgrades.

B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Concrete pavement: Section 02750.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: M147, T180, T191.

B. Source Quality Control:
1. Not less than 10 days prior to the beginning of work, inform the Engineer of proposed source of supply of materials, for testing by the Engineer.
2. Once approved, do not change source of supply.
3. Do not construe approval as approval of the entire location but as approval only insofar as material continues to conform to specified requirements.
4. Cooperate with the Engineer so that the Engineer may take samples and make tests as often as he deems necessary.
5. The Engineer has the right to reject material at the job site by visual inspection, pending sampling and testing.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Aggregate Base Material, General: AASHTO M147, Materials for Aggregate and Soil-Aggregate Base and Surface Courses, as amended in this section.

B. Use material which is free from frozen material.

C. Grading requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
2 inches	100
1 inch	70 - 100
3/4 inch	60 - 95
No. 4	40 - 75
No. 10	25 - 65
No. 40	10 - 45
No. 200*	2 - 15

***** Fraction passing the No. 200 sieve to be not greater than 2/3 of the fraction passing the No. 40 sieve.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. Place material using equipment designed for the purpose. Use equipment of size and weight necessary to shape material as shown and to compact material to specified minimum density.

B. Provide sufficient equipment to achieve specified compaction at rate consistent with rate of placement of base material.

C. Obtain approval of equipment prior to use on the work.

D. Maintain equipment in first class operating condition while in operation.

E. At the Engineers discretion, the Engineer may permit the use of graders for touching up and for working materials into areas not amenable to placing by other equipment, providing there is continuing conformance to the requirements.

F. Use approved mechanical tampers to compact material to the required density in areas that are not accessible to rollers.

3.02 PLACING MATERIAL:

A. Subgrade Preparation: In accordance with Section 02320.

B. Prior to placing the material, check the subgrade, make necessary repairs, and secure the Engineer's approval of the subgrade. Do not place on frozen subgrade. Do not dump the material directly on the subgrade.

C. Place material in its final location so as to provide uniformity of grading throughout work.

D. Use graders for touching up and for working materials into areas which do not permit use of other equipment providing there is continuing conformance to specified requirements and providing approval is obtained.

E. Place material in uniform layers so that each layer has compacted lift thickness of six inches maximum and three inches minimum.

F. Where thickness is shown or specified is more than six inches, place material in two or more layers of equal thickness so that specified requirements are met.

3.03 COMPACTION:

A. During placing and compacting, obtain moisture content and dry density within the allowable tolerances specified.

B. Compact each layer to required density before placing next layer.

C. Compact areas not accessible to rollers to required density by means of approved mechanical tampers.

D. Puddling or jetting is prohibited.

E. Density:
1. Compact material under curbs and gutters, gutters, curbs and pavement to 100 percent of maximum density at proper moisture content.
2. Compact material under sidewalks to 95 percent of maximum density at proper moisture content.

3.04 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
1. Construct base to the following tolerances:
a. Thickness of base: Plus zero or minus 3/8 inch.
b. Surface of base:
1) Plus 1/8 inch or minus 3/8 inch of elevation shown.
2) Deviation not more than 3/8 inch from steel straightedge as specified in Section 02750.
2. Maintain moisture content within one percent of optimum moisture content.

B. Tests: Determine optimum moisture content and maximum density in accordance with AASHTO T180, Moisture and Density Relations of Soils Using a 10-lb. Hammer and an 18-inch Drop, and tested in accordance with AASHTO T191, Density of Soil In-Place by the Sand-Cone Method.

3.05 MAINTENANCE:

A. Throughout placing and compacting, and until the placing of the succeeding pavement course, maintain base for pavement in specified condition.

3.06 DEFICIENT BASES:

A. Where directed, repair or remove and replace, with new material, pavement base that does not meet requirements.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use second version of SECTION 02725 BASE FOR PAVEMENTS for contracts where pavement base work is performed within the jurisdiction of the District of Columbia except as noted. (Use first version for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02740
(Version 2)[*1]

BITUMINOUS PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing bituminous pavements complete in place as shown; placed on bases prepared under Section 02725, Base for Pavements and under Section 02750, Concrete Pavement.

B. Related Work Specified Elsewhere:
1. Base for pavements: Section 02725.
2. Concrete pavement: Section 02750.

C. Definitions:
1. Equipment: This includes such specialized devices and tools as are customarily used in the construction of bituminous pavements; e.g., lutes, rakes, irons.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Certification:
   a. For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests.
2. Documentation:
   a. Job-mix formula:
      1) For each mix to be supplied submit job-mix formula based on expected production averages.
      2) In formula establish:
         a) Weight percent of total aggregate and of aggregate finer than each required sieve size.
         b) Weight percent of total mix of asphalt cement.
         c) Temperature of mix when placed.
      3) Maintain job-mix formula once approved.
   b. Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
      1) Mix type.
      2) Mix temperature.
      3) Identification of the truck.
      4) Tare weight of truck.
      5) Loaded weight of truck.
      6) Net weight of load.
      7) Time of leaving mix plant.
      8) Signature of the Engineer's plant representative.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: M6, M17, M20, M29, M43, M45, M76, M79, M81, M82, M140, T30, T164, T165, T168.

3. ASTM: D3515.

B. Sources of Supply:
1. Not less than 20 days prior to beginning the work, inform the Engineer of the source of the materials to be used and obtain approval.
2. Once approved, do not change source of supply.
3. Do not construe approval as approval of entire location but as approval only insofar as material continues to meet specified requirements.
4. Maintain quality of material. Material may be sampled and tested by the Engineer as often as the Engineer deems necessary.
5. The Engineer has the right to reject material at the job site by visual inspection pending sampling and testing.
6. Provide mix for a given area as defined by the Engineer from one mixing plant.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Delivery Trucks:
1. For transporting bituminous, mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40F.

B. Weighing of Bituminous Mixtures:
1. Provide approved truck scales having both dial and automatic printer or use public scales.
2. Use scales complying with applicable laws, ordinances and regulations governing use of scales.
3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy, and within the six months prior for use for the work. The Engineer has the option to require retesting and resealing.
4. At least once a week and whenever directed by the Engineer, check tare weight of each truck with full load of fuel and fitted with its normal equipment.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not place bituminous pavement on wet surfaces.
2. Place bituminous pavement only when temperature of air and base exceed 40F and when by U.S. Weather Bureau forecast, the temperature is expected to remain above 40F during the course of the work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Asphalt Cement: AASHTO M20, Penetration Grade 85-100.

B. Cut-Back Asphalt for Prime Coat: AASHTO M82, Grade MC-30 or MC-70 as conditions warrant.

C. Emulsified Asphalt for Tack Coat: As conditions warrant, use either of the following:
   1. AASHTO M81, Cut-Back Asphalt (Rapid-Curing Type), Grade RC-70.
   2. AASHTO M140, Emulsified Asphalt, Grade SS-1 or SS-1h, diluted with water in the volumetric ratio of three parts emulsion to one part water.

D. Aggregate: Coarse and fine aggregate free from substantial portions of serpentine or talc materials or carbonate aggregates containing less than 25 percent by weight insoluble residue retained between Size 10 and Size 200 sieves as determined by leaching samples with 6N hydrochloric acid.
   1. Coarse aggregate: Crushed stone, AASHTO M79 and AASHTO M76 except for grading. Weight loss not to exceed 15 percent by weight when subjected to five alterations of magnesium sulfate soundness test.
   2. Fine aggregate for hot asphaltic concrete: Consisting of one or a combination of the following materials:
      a. Material conforming to AASHTO M6 with the following additional requirements:
         1) When the material is subjected to five alternations of the magnesium sulfate soundness test, weighted loss not exceeding 12 percent by weight; amount of deleterious substances not exceeding following maximum permissible percent limits by weight:
            a) Clay lumps: 0.5.
            b) Coal and lignite: 0.25.
            c) Material passing size 200 sieve: 3.0.
            d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: 2.0.
      b. Material conforming to specified requirements for No. 10 coarse aggregate in accordance with AASHTO M43.
   3. Fine aggregate for sheet asphalt binder: AASHTO M45, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
8	100
50	15 - 40
100	0 - 10
200	0 - 5

THIS SPACE NOT USED.

4. Fine aggregate for sheet asphalt surface: AASHTO M29, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
4	100
10	95 - 100
40	55 - 80
80	15 - 40
200	0 - 5

5. Mineral filler: Limestone dust, hydrated lime, or portland cement, AASHTO M17; uniformly graded, non-plastic, free from lumps, balls or foreign materials, and having a maximum moisture content of 0.5 percent when incorporated into the bituminous mix.

6.

2.02 MIXES:

A. Provide mixes in accordance with ASTM D3515 and as specified.

B. Proportion constituents of job mixes within limits specified in Table 02740-1.

C. Submit mixes as directed for evaluation of job-mix formula, with bulk specific gravity determined in accordance with AASHTO T165.

2.03 TEMPERATURE OF MIXES:

A. Maintain temperature of mixes within plus-or-minus 25F of that given in job-mix formula. Temperature ranges as specified in Table 02740-2.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. General:
1. The requirements specified for equipment are pursuant to the equipment provisions of the General Provisions.
2. The requirements specified for equipment are not intended to be complete; rather, the intent is that the characteristic equipment be used to produce certain of the required results.
3. Suitability of the equipment is a determination made by the Engineer that the equipment will produce the required results.

B. Batch-Type Bituminous Mixing Plants: Of sufficient capacity to adequately handle the proposed construction; maintained in good mechanical condition; equipped with the necessary scales and measures to ensure proper proportioning of ingredients; and designed, coordinated and operated so as to produce a mixture within the job-mix tolerances. Ensure that defects which would adversely affect the proper functioning of the plants or the quality of the mixture are replaced or repaired immediately upon instruction from the Engineer.
1. Tanks for storage of bituminous material: Capable of heating the material, always under effective and positive control, to specified temperature requirements.

a. Heating: Accomplished by steam coils, electricity or other means so that no flame can come in contact with the heating tank, and so that uniform heating of the entire contents is provided.
b. Circulating system for the bituminous material: Of adequate size to ensure the proper and continuous circulation during the entire operating period.
c. Pipelines and fittings: Steam-jacketed or otherwise properly insulated to prevent heat loss.
d. Provide separate tanks and delivery lines for each grade of asphalt cement or liquid asphaltic material for mixtures to be produced in the same mixer unit.

2. Feeder for drier: Accurate mechanical means for uniformly feeding the aggregate into the drier so that a uniform production and a uniform temperature may be secured.
   a. Have each aggregate, except for mineral filler added cold, fed to a central elevator, conveyor or feeder by accurate mechanical means with adjustable gates that will deliver each aggregate in the desired proportion. When more than one cold elevator is used, feed each by a separate feeder unit with the individual controls integrated with a master total control.
   b. Set and lock the total and proportional controls when so directed by the Engineer.
3. Driers: Capable of drying and heating the aggregates as specified for any item, and of sufficient capacity to supply the mixing unit at its operating capacity. Drier is to continuously agitate the aggregates during the heating and drying process so that the temperature can be positively regulated.
4. Screening system for grading the aggregate: Shaker or vibrating type capable of screening the aggregates to specified sizes and proportions, producing a quantity of aggregate sufficient to keep the mixer operating at the rated plant capacity.
   a. Have screening system equipped with a chute or pipe for removal of oversized aggregate having the discharge end located so as not to create a hazard or nuisance.
   b. Revolving double-jacketed screens may be accepted if they give satisfactory performance of a maximum plant production.
5. Storage bins: Of sufficient capacity to supply the mixer when it is operating at full capacity; divided into at least three compartments arranged to ensure separate and adequate storage of appropriate proportions of aggregates; each compartment provided with an adequate overflow opening located so as to prevent backing up of material into other bins.
   a. Each compartment provided with its individual outlet gate, so designed and constructed that when closed there will be no leakage; gates cutting off quickly and completely.
   b. Have discharge points of overflow located so that they will not create a hazard or nuisance.
   c. Bins equipped with adequate tell-tale devices to indicate the position of the aggregate in the bins at the lower quarter points.
   d. Provide separate dry storage for the mineral filler.
6. Bituminous control unit: Satisfactory means, either by weighing, metering or volumetric measurements, to obtain the proper amount of bituminous material in the mix within the tolerance specified for the job-mix; with suitable means, either by steam-jacketing or other insulation, for maintaining the specified temperature of the bituminous material in the pipelines, meters, weigh buckets, spray bars, and other containers or flow lines.
7. Bitumen bucket (if a bucket is used for weighing the bituminous material): Capacity sufficient to hold not less than 20 percent of the weight of aggregate required for one batch; steam-jacketed or equipped with properly insulated electric heating units; and suspended on dial scales or beam scales so that the tare weight of bucket will be shown for each weighing.

a. Bucket equipped with tell-tale device to accurately control the net weight of bituminous material added to the mix to within two percent above or below the actual weight in pounds required.
b. Bucket arranged so that it will deliver molten bitumen in a thin uniform sheet or in multiple streams the full width of the mixer, except in the case of a rotary mixer where bitumen is sprayed.

8. Thermometric equipment: Have plant equipped with the following as approved:
   a. Armored thermometer reading from 200F to 400F, fixed at a suitable location so that the temperature of the bitumen at the bucket or spray bar can be determined.
   b. Dial-scale, mercury-activated thermometer, electric pyrometer or other approved thermometric instrument, so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate; of such accuracy that the temperature of the aggregate can be maintained within the limits specified; and so located so that its dial is in plain view of the drier fireman or feeder.
9. Mixing time: Positive means to govern the time of mixing and to maintain it constant unless changed by order of the Engineer.
10. Timing devices: Accurate timelock to control the operation of a complete mixing cycle by locking the weight box gate after the charging of the mixer, until the closing of the mixer gate at the completion of the cycle. Timeclock is to lock the bitumen bucket throughout the dry-mixing period and lock the mixer gate throughout the dry-mixing and wet-mixing periods.
    a. Control of the timing is to be flexible and capable of being set at intervals of not more than five seconds throughout cycles up to three minutes.
    b. A mechanical batch or box counter is to designed so as to register only upon the actuation of the bucket release and to preclude the register of dry batches or the register of material through the operation of pulling bins.
11. Plant scales: Either the beam or springless-dial type; of a standard make designed as an integral part of the plant; accurate to within one-half percent of the true weight of the load being weighed; having significant graduations that can be easily read to that degree of accuracy; and with dials and indicators in plain view of the operator when on the weighing platform.
    a. Beam-type scales: Balanced on knife edges and fulcrums that are kept clean and constructed so that they will not easily be thrown out of alignment and adjustment; each beam having a locking device which will permit the beam either to be suspended or thrown into action; a separate beam for each size aggregate and a tare beam for balancing the hopper; each aggregate beam equipped with an auxiliary dial or tell-tale that will indicate that the required load to the weighing hopper is being approached and will continue to indicate further movement of the beam after that.
        1) For weighing bituminous material, use beam-type scales that are provided with a tare beam and a full-capacity beam.
        2) Gradations: Two pounds or smaller.
    b. Dial scales: Springless and so constructed, installed, and maintained, to be free from vibration; of such size that the numerals on the dial can be easily read from a distance of 25 feet; dials of the compounding type having full complements of index pointers.
        1) For weighing asphalt cement, capacity equal to or less than two times the maximum weight of the material to be weighed.
        2) Graduations: Such that they can be easily read to the nearest two pounds.
    c. Weigh box or hopper: Provide means for accurately weighing each bin size of aggregate in a weigh box or hopper suspended on scales and of sufficient size to hold a full batch without hand raking or running over; with gates on both bins and hopper constructed so as to prevent leakage when they are

closed. Have container supported on knife edges or fulcrums constructed so that it will not easily be thrown out of alignment or adjustment; with edges, ends and sides free from contact with supporting parts that could possibly affect proper weighing; and with adequate clearance of the parts to prevent accumulation of foreign materials. In plants where the weigh box is enclosed for the purpose of minimizing dust nuisance, have some provision made to permit sampling the materials by the Engineer as discharge is made from the storage bins.

d. Provide ten 50-pound standard test weights at each plant for testing weighing equipment.

12. Mixer unit: Batch mixer of an approved twin-pugmill type or rotary-drum type, with a batch capacity of not less than 2,000 pounds, and capable of producing a uniform mixture within the job-mix tolerances specified; constructed as to prevent leakage of contents until the batch is to be discharged.
    a. If mixer is the pugmill type, have the clearance of the blades from fixed and moving parts not to exceed 3/4 inch, unless the maximum aggregate particle exceeds 1-1/2 inches.
    b. If not enclosed, equip the mixer box with a dust hood to prevent loss of dust. When so enclosed, make provision to permit visual inspection of mixing operation by the Engineer.
13. Dust collectors: When plant is located where dust may be objectionable or become a nuisance or where dust interferes with the efficiency of the operation of the plant, provide proper housing, mixing covers, or dust collecting systems. Make provision to dispose of the material so collected or to return it uniformly to the mixture, as the Engineer may direct.
14. Safety Requirements:
    a. Provide a mixer platform sufficiently rigid and of ample size to provide for safe and convenient access to the mixer and pertinent equipment.
    b. Place adequate and safe stairways to the mixer platform and guarded ladders to other plant units at points where accessibility is necessary during plant operations.
    c. Thoroughly guard gears, pulleys, chains, sprockets and other dangerous moving parts.
    d. Always maintain a clear, ample and unobstructed passage in and around the truck loading space. Keep this space free from drippings from the mixing platform.

C. Continuous-Type Bituminous Mixing Plants: Meet the requirements for batch-type bituminous mixing plants, except for the requirements as to scales and weighing equipment and the requirements for the mixer unit which do not apply. The following are required in continuous mixing plant:

1. Gradation control unit: Means for accurately proportioning aggregate from each bin either by weighing or by volumetric measurement. When gradation control is by volume, have the unit include a feeder mounted under the bin compartments. Equip each bin with an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each bin compartment. Make the orifice of adequate dimensions to provide a positive feed without bridging and with one dimension adjustable by positive mechanical means provided with a lock. Provide indicators graduated from sufficient subdivisions of inches to provide accuracy of measurements, on each gate to show the size of gate opening. If mineral filler is required, proportion it separately, and add it to the mix in such a manner as to ensure uniform distribution.
2. Weight Calibration of Aggregate Feed: Have plant include a means for calibration of gate openings with weight test samples. Allow materials fed out of the bins through individual orifices to be bypassed to a suitable test box or boxes, the material from each compartment being confined separately. Equip the plant to

handle conveniently test samples of size adequate to provide an accurate gate calibration commensurate with the aggregate size, the gate opening, and the plant capacity setup. Provide an accurate platform scale with a minimum capacity of 500 pounds.

3. Synchronization of Aggregate Feed and Bitumen Feed: Provide satisfactory means to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning source. Accomplish this control by interlocking mechanical means or by another positive method under the control of the Engineer.
4. Mixer Unit for Continuous Method: Continuous mixer of an approved twin-pugmill type, steam-jacketed and capable of producing a uniform mixture within the job-mix tolerances. Use paddles that are adjustable for angular position on the shafts and reversible to retard the flow of the mix. Have the mixer carry a manufacturer's plate stating the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Provide charts showing the rate of feed of aggregate per minute required, controlled by weight method under the following formula. The weights will be determined by tests made by the Engineer.

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in lbs.}}{\text{Pugmill output in lbs./sec.}}$$

D. Trucks for Transporting Bituminous Mixtures: Solid metal, dump-type bed, clean and smooth; with a tight-fitting rear gate to prevent loss of materials while in transit.

1. Spray the inside surface of the bed with a minimum amount of approved thin oil or a mixture of lime and water proportioned at a rate of 100 pounds of lime to 50 gallons of water, prior to loading, to prevent adhesion of the mixture to the bed. Kerosene and gasoline will not be approved nor will the use of excessive quantities of approved oil be permitted.
2. Equip each truck with a canvas or other covering of sufficient size to cover the material and protect it from weather. To prevent excessive temperature loss while in transit, equip the trucks with insulating units composed of wood or other approved material between October 15 and March 15, when so directed by the Engineer.
3. Do not use trucks with appreciable oil leakage that may cause damage to the new bituminous construction.

E. Bituminous Spreading and Finishing Machines: Use spreading and finishing machine that operates without side forms and of a self-propelled type approved by the Engineer and equipped with the following features:

1. An efficient steering device of both forward and reverse traveling speeds.
2. Adjustments, of the manufacturer's standard design, that permit the bituminous material to be placed to a maximum width of not less than 12 feet and to a minimum width of 8 feet; the adjustments made in increments of one foot or less.
3. Devices to adjust the thickness of material being placed, with suitable hopper for receiving the material, and with distributing screws, rake bars, or similar for evenly placing the mixture in front of the screed.
4. The screed is a strike-off device operated by cutting, crowding or other practicable action that is effective on the bituminous mixture being placed, that is equipped with a heater, that produces a finished surface of uniform texture, and that is adjustable to the shape of the cross section of the finished surface.
5. Joint-leveling or joint-blending devices for smoothing and adjusting longitudinal joints between adjacent layers of the same thickness.
6. Ability to spread the bituminous mixture without tearing the surface and to strike a finish that is smooth, true to cross section, uniform in density and texture, and free from hollows, corrugations and other irregularities.

F. Tools for Finishing Asphalt Surfaces:

1. Asphalt lute: Wood, with a blade six feet in length, six inches in width, and one-half inch in thickness; edged on the contact surface; with the handle 16 feet in length, to one end of which the blade is firmly affixed with adequate bracing.
2. Rakes: Metal, not be less than 14 inches wide; with tines of sufficient depth to penetrate and rake the material for its full depth.
3. Smoothing irons: Metal, weighing not less than 40 pounds; with bearing surface not be less than 80 square inches.
4. Hand tampers for compaction of bituminous material in locations inaccessible to rollers: Metal, weighing not less than 25 pounds, with tamping face of not less than 48 square inches.

G. Rollers: Use rollers that are in first-class mechanical condition, complying with the requirements for the individual items as to classifications, weights and service requirements. Use tandem and three-wheel rollers that are power-driven, always capable of being reversed smoothly, and free from backlash, loose-link motion, faulty steering mechanism, and worn king bolts and bearings. A roller of these types that has been improperly weighted or that has in any way been thrown out of its original balance by the application of attachments not approved or not the manufacturer's original standard design will not be permitted on the project; nor will any roller that does not have displayed thereon in permanent legible characters the manufacturer's guaranteed net operating weight as distributed on each axle be permitted on the project. The net operating weight is the actual net weight plus one-half of the total maximum weight of fuel and water. Ensure that rolls have closely fitting spring scrapers, adjustable for forward and reverse motion.
   1. Two-Axle Tandem Rollers: Of rigid construction with the following features:
      a. Having a low center of gravity and balanced on the longitudinal axis, smooth operating friction clutches of the reversing type, smooth operating brakes, both hand-operated and power-operated steering devices.
      b. The type of driving mechanism is to be such as to give the lowest side clearance possible.
      c. Equipped with a water sprinkling system having a tank capacity as indicated in the table below, with the water piped to the spray pipes on each roll, the spray pipe extending the full width of the roll and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rolling surface, and having separate valves to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.
      d. Minimum compression per inch of width of drive roll may include only the net operating weight of the roller, with the distribution of weight such that not more than 68 percent of the total gross weight is placed upon the drive roll.

THIS SPACE NOT USED

Manufacturer's rating, tons	5 - 6	10 - 12	15
Minimum diameter, drive roll, inches	42	60	70
Minimum diameter, guide roll, inches	36	48	50
Minimum rolling width, inches	20	20	20
Minimum compression, per inch width of drive roll, pounds	130	220	300
Minimum water sprinkling tank capacity, gallons	70	100	125

2. Three-Axle Tandem Rollers: Of rigid construction with the following features:
   a. Having a low center of gravity and balanced on the longitudinal axis, smooth operating friction clutches of the reversing type, smooth operating brakes of ample capacity, and power-operated steering devices, with both guide rolls steerable and the ratio of steering synchronized.
   b. The type of driving mechanism is to be such as to give the lowest side clearance possible.
   c. Equipped with a water sprinkling system having a tank capacity as indicated in the table below, with the water piped to the spray pipes on each roll, the spray pipe extending the full width of the roll and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rolling surface, and having separate valves to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.
   d. Minimum compression per inch of width of drive roll may include only the net operating weight of the roller, with the distribution of weight such that not more than 68 percent of the total gross weight is placed upon the drive roll.

THIS SPACE NOT USED

Manufacturer's rating, tons	12 - 20
Minimum diameter, drive roll, inches	60
Minimum diameter, guide roll, inches	48
Minimum rolling width, inches	54
Minimum compression, per inch width of drive roll, pounds, all three rollers in same plane	210
Minimum water sprinkling tank capacity, gallons	200

3. Pneumatic-Tire Rollers: Provide the following features:
   a. Multiple-axle, multiple-wheel type with smooth-tread pneumatic tires of equal size staggered on the axles at such spacing and overlaps as will provide uniform compactive pressure for the full compacting width of the roller when operating. In operating pneumatic-tire rollers, have the tires inflated to the same air pressure, within a tolerance of five pounds, and to the pressure required or designated for use.
   b. If provided, have oscillation of the wheels in a vertical plane only.
   c. Capable of being ballasted sufficiently to bring its loaded weight to at least 2-1/2 times its own weight and of exerting compactive ground contact pressures of at least 80 psi. Have the roller ballasted to the extent required or designated; and within limits prescribed above, so that the roller provides the compactive ground pressure per square inch that is most efficient under the conditions and for the purpose of its use, and as directed.
   d. Furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of tire loadings for each type and size compactor tire furnished.
4. Trench Rollers: Provide the following features:
   a. Constructed so that the guide roll or wheel either operates in tandem with the compression roll on the area to be compacted or in tandem with the auxiliary wheel or roll.
   b. An auxiliary wheel or roll that operates outside the area to be compacted, mounted upon an axle having height adjustability so that the contact surface of the auxiliary wheel or roll is capable of being adjusted at least 10 inches above and two inches below the rolling plane of the compression roll or the amount necessary to compact the soils base to the plan elevation. If the guide roll or wheel operates in tandem with the auxiliary roll or wheel, it may or may not be adjustable as to height. Have the auxiliary wheel or roll operate upon the surface of the pavement adjacent to the area to be compacted, and at such a distance from the pavement edge as to cause no change thereto. Keep the auxiliary wheel or roll in such adjustment as to

height that the compression roll will develop a smooth compacted surface true to crown.

c. Smooth operating friction clutches of the reversing type, smooth operating brake of ample capacity, and either hand-operated or power-operated steering devices.

d. Compression roll may be of hollow-type construction and the minimum weight secured by liquid ballast; minimum 300 pounds compression per inch of width of compression roll; and minimum width of compaction at least 15 inches.

e. Maximum rolling speed 1-1/2 miles per hour.

f. Equipped with sprinkling system having a tank or tanks with total capacity of not less than 50 gallons, with the water piped to the spray pipes on each roll, the spray pipes extending the full width of rolls and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rims of the rolls, and having separate to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.

3.02 BASE PREPARATION:

A. Prior to placing bituminous mixture, check line, grade and cross section of underlying course. Repair defective areas.

B. Have base approved, before beginning installation work.

C. Aggregate and Soil Aggregate Bases:

1. Apply primer using equipment designed for that purpose.
2. When base is dry, uniformly apply primer at rate of application directed, approximately 0.15 gallons per square yard.
3. Allow primer to cure satisfactorily before placing mix.

D. Portland Cement Concrete, Bituminous and Brick Pavement Bases:

1. Apply tack coat using equipment designed for that purpose.
2. Prior applying tack coat, satisfactorily clean the base and verify that base is dry at time of application.
3. Apply tack coat uniformly to clean dry base at rate as directed by the Engineer, 0.02 to 0.05 gallons per square yard.
4. The Engineer has the right to direct omission of tack coat over new bituminous courses, or to order the tack coat to be "run in" by the use of trucks or other rubber-tire equipment.
5. Ensure that surface has cured and is satisfactorily tacky before placing mix.

E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes and similar structures.

3.03 PLACING MIX:

A. Place mix by two or more machines operating in echelon in such manner that joints between lanes are hot. Keep machines clean and free from accumulations of asphaltic materials by acceptable means.

B. If equipment being used produces tracks, pulling, indented areas or other permanent blemishes in material being spread, remove such equipment from site and substitute other approved spreading and finishing equipment.

C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.

D. Adjacent to headers, gutters, manholes and similar structures, place surface course so that finished surface is 1/4-inch above edge of structure.

E. When the Engineer considers it impractical to place mix with two machines, one machine will be permitted. Treat joints created by such operation as cold joints.

3.04 COMPACTION:

A. Compact as soon as the condition of the mix permits. Have rollers start longitudinally at the extreme sides and proceed toward the center of pavement, overlapping on each successive trip by one-half the width of the rear roll. Diagonally roll surface courses in two directions, the second diagonal crossing the lines of the first. Have rolling proceed in one continuous operation until roller marks are eliminated and until courses required density, specified below under Tolerances.

B. Perform breakdown rolling with a three-wheel steel-wheel roller designed for the purpose; the weight as required for job conditions.

C. Perform initial finish rolling and final rolling with at least one 10-ton tandem steel-wheel roller and one three-axle tandem steel-wheel roller designed for the purpose.

D. When temperature is below 50F, the Engineer may direct the use of a 5-ton tandem roller to seal the surface.

E. Perform intermediate rolling of sheet asphalt with tandem steel-wheel rollers or with self-propelled pneumatic-tire rollers designed for the purpose, as conditions warrant.

F. Perform intermediate rolling of hot asphaltic concrete with self-propelled pneumatic-tire rollers designed for the purpose.

G. For binder courses adjacent to structures where use of rollers is impractical, use hand tampers designed for the purpose.

H. Use trench rollers designed for the purpose where necessary.

3.05 COLD JOINTS:

A. Avoid cold joints; permitted only when necessary in the opinion of the Engineer.

B. Where mix is to be placed against cold asphaltic material, cut back the cold asphaltic material with a power masonry saw a minimum of three inches so that a vertical face of compacted full-thickness material is exposed. Treat this cut face as a contact surface.

3.06 BULKHEADS:

A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.

B. Construct cold joint as specified when work is resumed.

3.07 HANDWORK:

A. When approved, perform bituminous paving work by hand in areas inaccessible to machines.

B. Undertake handwork using equipment designed and approved for purpose.

C. Perform handwork so that resulting paving meets specified requirements.

3.08 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Thickness: Place bituminous pavement to within tolerance of plus-or-minus 1/8 inch of thickness shown.
   2. Surfaces: Construct surfaces to the following tolerances:
      a. Binder courses to within plus-or-minus 3/8 inch of elevation shown.
      b. Surface courses to within plus-or-minus 3/16 inch of elevation shown.
      c. Surfaces to deviate no more than 1/8 inch in the length of 10-foot steel straightedge, not cumulative.
      d. During compacting, screed surface using straightedge as specified in Section 02750. Adjust rolling procedures so that tolerances are met.
   3. Densities required:
      a. Binder courses: 94 percent of Marshall density.
      b. Surface courses: 96 percent of Marshall density.

B. Testing:
   1. Mixes:
      a. During course of the work submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and AASHTO T164 on random samples selected in accordance with AASHTO T168.
   2. Cores: Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or two cores per shift, whichever is greater.
      a. Wherever deficient pavement is discovered take such additional cores as directed.
      b. Repair core holes promptly using the same mix that was cored; where cores are taken through both binder course and surface course simultaneously, use surface course mix for repair work.

3.09 PROTECTION OF BITUMINOUS PAVEMENT:

A. Obtain approval for use of pavement by public and construction traffic.

B. Do not permit traffic to cross uncompleted longitudinal joints.

3.10 DEFICIENT PAVEMENT:

A. Where directed, replace with new material or repair bituminous pavement that does not meet specified requirements..

THIS SPACE NOT USED

TABLE 02740-1 CONSTITUENT PROPORTIONS					
GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT					
SIEVE	SHEET ASPHALT		HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE:
	BINDER	SURFACE	BINDER	SURFACE	ALL MIXES
1 inch	- -	- -	100	- -	±7
3/4 inch	- -	- -	90 - 100	- -	±7
1/2 inch	100	- -	- -	100	±7
3/8 inch	85 - 100	- -	60 - 85	85 - 100	±7
No. 4	35 - 55	100	45 - 65	55 - 80	±7
No. 10	20 - 35	95 - 100	30 - 50	40 - 65	±6
No. 40	- -	55 - 92	10 - 25	10 - 30	±6
No. 80	- -	20 - 60	3 - 15	3 - 15	±4
No. 200	0 - 5	9 - 20	2 - 8	2 - 8	±3
	ASPHALTIC CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE				
	4.0 - 7.0	8.5 - 11.5	5.0 - 8.0	5.0 - 8.0	+0.5

* Notwithstanding tolerances, supply mixes within specified grading limits.

TABLE 02740-2 MIX TEMPERATURE RANGES				
MIX	TEMPERATURES, DEGREES F			
	PLANT			STREET
	AGGREGATE	ASPHALT CEMENT	TOTAL MIX	
Sheet Asphalt Binder	250 - 325	250 - 325	250 - 325	250 - 325
Sheet Asphalt Surface	300 - 375	250 - 350	300 - 375	275 - 350
Hot Asphaltic Concrete	250 - 325	250 - 325	250 - 325	250 - 325

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use second version of SECTION 02740 BITUMINOUS PAVEMENT for contracts where bituminous pavement work is performed within the jurisdiction of the District of Columbia except as noted. (Use first version for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02750
(Version 2)[*1]

CONCRETE PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing portland cement concrete pavements complete in place as shown.

B. Related Work Specified Elsewhere:
1. Base for pavements: Section 02725.
2. Concrete reinforcement: Section 03200.
3. Cast-in-place structural concrete: Section 03300.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements with the additional requirements as specified for each:

A. Shop Drawings:
1. Joint devices.

B. Certification: As specified in Section 03300, including design mixes.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: M33, M74, M81, M148, M153, M171, M182, M194, M220, M227, T51 T148.
3. FS: SS-S-164, SS-S-195, TT-P-86, TT-S-00227.
4. ASTM: A185, A370, A615, C33, C294, C920.

B. Concrete: Conform to quality assurance requirements as specified in Section 03300 and this section.

C. Testing: Subject concrete for pavements to test procedures specified in Section 03300.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Aggregates and Cement: As specified in Section 03300.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not place concrete on frozen soil base.
2. Apply joint sealer when the air temperature is 50F or higher.

B. Refrain from placing concrete while the temperature is lower than 40F or when by the National Weather Service forecast it may be expected to reach 40F or lower during the 24-hour period following placement of concrete.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Subgrade Paper: AASHTO M74.

B. Polyethylene sheet and tape: AASHTO M171, white opaque for curing.

C. Welded Wire Fabric: Welded steel-wire fabric, ASTM A185.

D. Bituminous Paint: AASHTO M81, Grade RC-250.

E. Joint Devices: Use joint devices which are so designed that, when under the load of fresh concrete, the parts will deviate no more than 1/4 inch from the position shown and not more than 1/8 inch from the specified tolerances, and that the finish joints can be constructed to these same tolerances. Provide joint devices complete with accessories, approved supporting devices, and installing devices and equipment.
   1. Tie bars: ASTM A615, Grade 60.
   2. Tie rod assemblies: Tensile requirements of AASHTO M227, Grade 80 based on measured cross-sectional area of unthreaded portion of bar when tested in assembled condition in accordance with ASTM A370.
   3. Dowels:
      a. Plain round bars, AASHTO M227, Grade 80 coated with paint, FS TT-P-86, Type I.
      b. Dowel sleeves in accordance with the following:
         1) Snug fit with dowel bar.
         2) Closed end.
         3) Limit stop for dowel approximately one inch from closed end.
         4) Sufficient rigidity to prevent entry of fresh concrete and collapse during construction.
   4. Grease for Dowels: Approved water-resistant graphite grease.
   5. Preformed joint fillers: AASHTO M153, Type II.
   6. Preformed Plank: Rigid plank of asphalt hardboard or similar material approved by the Engineer.

F. Joint Sealer Materials:
   1. Joint sealing compound: Materials so proportioned that joints will be satisfactorily sealed from moisture and other foreign matter. Add appropriate tinting during manufacture, if necessary, to produce a black color.
      a. Hot-poured joint sealing compound for joints in concrete pavement: FS SS-S-164 except the use of ground rubber scrap is prohibited. Ductility of not less than 40 centimeter in accordance with AASHTO T51; flow at 140F not greater than 1.0 centimeter.
      b. Cold-applied joint sealing compound for joints in concrete pavement: FS SS-S-195.
      c. Joint sealing compound for joints between concrete pavement and other structures: FS TT-S-00227.

G. Preformed joint seals: AASHTO M220.

H. Burlap: AASHTO M182, Class 3.

I. Waterproof paper: AASHTO M171.

J. White burlap-polyethylene sheet shall conform to AASHTO Designation M171.

K. Liquid Membrane Forming Curing Compounds: AASHTO M148, Type 1, resin base, wax-free.

L. Concrete: Section 03300, Class 3500, air-entrained, amended as follows:
1. Portland cement: Type I.
2. Minimum cement content: Six bags per cubic yard of concrete.
3. Maximum water content: 0.45 maximum water cement ratio.
4. Air content: 6-1/2 percent plus-or-minus 1-1/2 percent by volume.
5. Slump: 2-1/2 inches plus-or-minus 1/2 inch.
6. Water reducing admixture: AASHTO M194, Type A or D as directed.
7. Coarse aggregate:
   a. Size: ASTM C33 Size No. 67 or a combination of Size No. 4 and Size No. 67.
   b. Deleterious materials: Maximum amount of soft fragments, 2.0 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; and material passing Size 200 sieve 0.5 percent by weight.
   c. Maximum abrasion loss: 40 percent by weight.
8. Fine aggregate:
   a. Deleterious material: Maximum amount of friable particles, 0.5 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; material passing Size 200 sieve three percent maximum by weight.
9. For bridge decks and bridge sidewalks: Use only crushed trap rock aggregate, trap rock to be diabase rock, ASTM C294.

M. High-Early-Strength Concrete: As specified for concrete and modified to produce high-early-strength concrete by one or a combination of the following methods.
1. Substitution of Type III or Type I cement in approved mix.
2. Addition of Type I cement to the approved mix, but so that the total cement does not exceed eight bags per cubic yard of concrete.
3. Addition of an approved accelerating admixture to approved mix as specified in Section 03300.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. General: See General Provision's Article on equipment.
1. Provide suitable equipment in sufficient quantity and sizes to perform work as specified and shown.
2. Maintain machinery and equipment on site in first class working condition. Provide necessary tools and supplies for maintenance.
3. The term EQUIPMENT includes such specialized devices and tools that are customarily used in the construction of concrete pavements. The requirements for equipment given are not intended to be complete; rather, the intent is that characteristic equipment be used to produce certain of the required results. The suitability of the equipment is a determination made by the Engineer that the equipment will produce the required results.

A. Concrete Spreading Machines: Power driven spreaders capable of spreading concrete to the full width and depth specified as it is delivered and as follows:
1. Standard-width machines with adjustments up to five feet.
2. Controls conveniently grouped in easy reach of the operator.
3. Multiple speeds in both reverse and forward gear.

4. Capable of spreading concrete to both the depth specified for reinforcement and the full thickness of the slab, without segregation and without interfering with the joints or reinforcement.
5. Not disturbing the forms due to lateral pressure of the spreading operation; the weight of the machines of such amount and so distributed as not to cause settlement of the forms.
6. Equipped with dismountable rims to be used when operating on concrete.
7. Provided with suitable means to keep material off the wheel and the top of the forms or slab.
8. Spreading accomplished by either a screw, blade, or other suitable device of the reversing type, followed by a strike-off screed; the strike-off screed adjustable to the specified crown and section.

B. Internal Vibrators Operated Independently of Spreading or Finishing Machines: Use approved type of internal vibrators such as the spud-type, for compacting pavement concrete at joints and edges, operating at a frequency capable of producing at least 5,000 pulsations per minute, and with sufficient cable to permit being moved to any location directed by the Engineer. Do not use vibrators of such weight as to be unwieldy in application.

C. Concrete Finishing Machines:
1. Power-driven and of the transverse-screed type.
2. Equipped with traction wheel or wheels with dismountable rims to be used when operating on concrete.
3. Equipped with two screeds, maintained in the best possible condition and adjustment throughout their use: Front screed used for striking off excess concrete to exact grade and crown; the rear screed used for finishing and smoothing operation.
4. Screeds constructed of steel, be capable of being adjusted to the specified cross section, and be of such rigidity as to produce the specified crown and cross section.
5. Each screed of the floating or suspended type, at least 1-1/2 feet longer than the width between the forms, and easily and quickly adjustable to the width required.
6. Both machine and screeds are to have variable speeds and independently controlled.
7. The weight of the machines of such amount and so distributed as not to cause settlement of the forms upon which operated.
8. Provided with suitable means to keep material off the wheel and the top of the forms or slab.

D. Straightedges: Ten feet long, made of metal with handles suitable for ease of use, and rigidly constructed so that there will be no deflection exceeding 1/32 inch.

E. Templates: Constructed to extend from form to form and to ride on the form, equipped with adjustable tines spaced at six-inch intervals, and rigidly constructed that there will be no deflection exceeding 1/32 inch.

3.02 BASE:

A. Base Preparation: In accordance with Section 02725.

B. Check previously placed base for grade and crown with templates and straightedges for compliance with tolerances specified in Section 02725.

C. Correct deficiencies in grade, contour and compaction.

D. Obtain approval of base prior to placing forms and impervious material.

3.03 SETTING FORMS:

A. Unless concrete is placed against abutting structures, use steel forms to maintain concrete within required tolerance and to support paving equipment.

B. Use flexible steel forms for curve radii less than 250 feet. For small radius curves and non-standard closures, use approved wood forms. Provide properly drilled forms to accommodate tie rod assemblies.

C. Set forms accurately and firmly to line and grade throughout entire length of approved base.

D. Set forms sufficiently ahead of other work to avoid conflict during operations.

E. Concurrent with setting of forms, cover base with layer of impervious material of either subgrade paper or polyethylene sheet.
   1. Subgrade paper: Overlap adjacent strips at least four inches and ends not less than 12 inches.
   2. Polyethylene sheet: Overlap sides at least 12 inches.
   3. Maintain cover intact until concrete is placed.

F. Apply one coat of bituminous paint to contact areas of abutting structures and previously placed slabs.

3.04 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Joints and joint devices: Maximum deviation of 1/4 inch from position shown and 1/8 inch from ten-foot steel straightedge.
   2. Dowels: Aligned to tolerance of not more than 1/8 inch in 12 inches.
   3. Fabric reinforcement:
      a. Clearance from vertical surfaces and joints: Minus 1/4 inch or plus 1/2 inch.
      b. Clearance from top and bottom surfaces: Plus-or-minus 1/4 inch.
      c. Clearance from top surface of additional reinforcing at penetrating structures: Plus-or-minus 1/8 inch.
   4. Top surface of concrete: Maximum deviation of 1/8 inch from ten-foot steel straightedge and within plus-or-minus 1/8 inch of the required elevation.
   5. Grooves for joints: Within minus 1/16 inch or plus zero inch of dimensions shown.
   6. Thickness of concrete pavement: Within minus 1/8 inch of the thickness shown, in accordance with AASHTO T148.

B. Testing of Concrete:
   1. Conform to requirements specified in Section 03300.

3.05 JOINT DEVICES:

A. General:
   1. Place and secure joint devices to ensure that deviation does not exceed specified tolerances. Finish joints to such tolerances.
   2. Provide acceptable means of splicing.
   3. Provide satisfactory gages for checking position of joint devices.
   4. Where joints are to be completed after placing concrete, mark location of joint devices so as to permit installation of joint to tolerances specified.
   5. Where options for construction are permitted, use approved method.
   6. Do not disturb joint devices. Do not permit workers to step on joint devices. Realign devices immediately if displaced.
   7. Hold initial installation of devices firmly in place by tap bolts installed in holes drilled in forms. If holes in forms have been formed by method other than drilling, use steel washers in addition to tap bolts. After removal of forms replace tap bolts until

adjoining subgrade is ready for concrete placement. Remove tap bolts and install remainder of tie devices prior to placing adjoining slab. Apply heavy coating of bituminous paint prior to placing concrete for adjacent slab.

B. Construction.

1. Longitudinal: The longitudinal joint at a previously placed slab and the joint between a slab and abutting curb and gutter are longitudinal construction joints.
   a. For these joints, with the exception of the ones at the curb and gutter sections, use a tongue-and-groove joint of an isosceles trapezoidal section one inch in height with the bases two inches and 2-1/2 inches, respectively; with the groove located as shown
   b. Tie the separately constructed slab sections together by the installation of longitudinal tie devices.
   c. The groove for concrete pavement for surface course may be made by forming or sawing as specified below, or by preformed plank left in place.
   d. Coat edges of the slab first constructed with heavy coat of bituminous paint prior to placing concrete for the adjacent slab.
2. Transverse joints: Make transverse construction joints only at a planned transverse expansion or contraction joint. Accordingly, have transverse construction joint devices conform to the requirements for the particular type of joint.

C. Contraction Joints:

1. Provide longitudinal contraction joints between previously placed slabs and new slabs and between slabs and abutting curbs and gutters.
   a. Tie longitudinal contraction joints together by installation of 1/2-inch tie rods or tie-rod assemblies 30 inches long placed across longitudinal contraction joint and spaced as shown. Do not install tie rods or tie-rod assemblies closer than 18 inches to transverse joints.
   b. Make groove for contraction joints by formwork, sawing or leaving filler in place.

D. Expansion Joints and Joint Filler:

1. Make grooves for expansion joints by forming. Where grooves are made by device, use approved device of such design that work can be properly performed.
   a. Prepare preformed expansion joint filler in greatest length possible and no less than ten feet.
   b. Cut filler for joints transverse to the slab in a single piece of the required shape.
   c. Cut pieces for curb and gutter as directed to exact size, from larger pieces.
   d. When splicing joint filler, butt tightly to prevent penetration of concrete between adjacent strips of joint filler.
   e. For longitudinal joints, except at curb and gutter sections, use preformed tongue and groove filler as shown.
   f. Where dowels or other approved load-transfer devices have to penetrate joint filler, properly locate and drill holes of correct size or diameter through filler at required intervals to receive bars and to achieve tight fit.
   g. Make groove for cement pavement for surface course by forming, sawing or leaving preformed joint in place.
   h. Protect preformed joint filler during placing of concrete.

3.06 PLACING REINFORCEMENT:

A. Install welded steel wire fabric in flat sheets where shown in accordance with Section 03200.

B. Unless otherwise noted, use wire fabric as follows:

Slab Thickness (Inches)	Roadway Width	
	Equal to or less than 24'-0"	Greater than 24'-0"
	Pounds/100 Square Feet	Pounds/100 Square Feet
6	44	46
8	51	54
10	61	69

C. Place wire fabric to clear vertical surfaces and joints by two inches and within tolerances specified. Lap sheets distance equal to spacing of wires and tie securely.

D. Place two layers of wire fabric in concrete pavements over trench cuts, each layer to be of weight and type as specified for thickness of concrete. Position each layer two inches clear of top and bottom surfaces of slab and within tolerance specified. Extend each layer nine inches beyond sides of trench.

E. Where other structures, such as manholes, penetrate concrete pavements, place wire fabric on one inch centers in each direction so that there is a minimum of two feet of fabric extending horizontally around perimeter of structure. Install layer of fabric one inch clear of top surface of slab and within tolerance specified.

F. In surface courses, place wire fabric two inches clear of top surface of slab and within tolerance specified.

G. Install layer of wire fabric to serve as top layer over trenches. Install additional fabric around penetrations.

H. Except for pavements over trench cuts and around penetrations, do not place wire fabric in base course.

3.07 PLACING CONCRETE:

A. Supply and place portland cement concrete as specified in Section 03300, with the following additional requirements:

1. Place concrete only during daylight unless otherwise approved. If placement is authorized during darkness provide adequate lighting system.
2. Do not place concrete at temperatures below 40F unless otherwise approved; nor place concrete on a frozen base.
3. Prior to placing concrete around poles, manholes or other structures projecting through pavement, coat such structures heavily with bituminous paint.
4. Place concrete to the full thickness, deposited in successive batches for full width of slab by means of discharging device which does not cause segregation of materials.
5. Compact concrete thoroughly during placement.
6. Place concrete mechanical spreaders except where hand methods for spreading are approved. When spreading by hand, employ sufficient work force for leveling, spading and spreading concrete in front of screed. Do not use rakes for handling concrete.
7. Deposit concrete as near as practicable to joints but not touching expansion and contraction joint devices. Shovel concrete to height approximately two inches more than depth of the joint. As soon as forms are removed, clean ends of expansion joints of concrete and expose full width of preformed joint filler for full depth of slab.

Place concrete against previously constructed slabs only after ends of preformed joint filler have been so cleaned and ends of performed joint filler in slab being poured have been neatly and firmly butted.

8. Where wire fabric is required, place concrete in layers so that wire fabric may be properly placed. Requirements for machine placing and for vibration apply for each layer. Place layers and wire fabric, large wires running in longitudinal direction in such rapid sequence that monolithic slab will result.
9. Compact concrete both by internal and surface vibration. Vibrators may be combined with spreading and finishing machines. Compact concrete adjacent to forms, joints, existing concrete or other structures by use of spud vibrator. Insert vibrator in concrete and work along entire length. Avoid contact with joint devices or underlying base. Evidence of honeycomb or lack of compaction constitute basis for rejection of concrete pavement as deficient.
10. Construction Joints:
    a. Form construction joints where it is necessary and approved to stop concreting for 30 minutes or longer, by staking in a bulkhead and finishing the concrete to the bulkhead.
    b. If, due to an emergency, concreting must be stopped within less than ten feet of a previously formed joint of any type, remove the concrete to the joint prior to resuming the placing of the slab.

3.08 INITIAL FINISHING, FLOATING AND FINAL FINISHING:

A. Give concrete initial finish by use of finishing machines operated so as to minimize formation of laitance and to give required uniformity of surface and compaction. Remove laitance in approved manner.

B. Avoid prolonged operation over a given area. Operate the machine over each area of pavement as directed and only as many times and at such intervals as required to give the proper compaction and uniformity of surface.

C. Keep tops of forms clean to permit true and accurate movement of machine.

D. On completion of screeding, bring surface to smooth finish by use of floats, eight inches wide and a minimum of four feet long, with handles at least four feet longer than width of slab and not less than 16 feet long.

E. Operate float transversely with combined longitudinal and transverse motion for sufficient number of passes to smooth ridges and fill depressions.

F. On completion of floating operations, screed top surface of concrete with deviation not exceeding 1/8 inch from straightedge and within tolerance specified for required elevation. Correct deficiencies by handwork if approved.

G. After floating and verifying that surface is within specified tolerances, drag surface in longitudinal direction with longitudinal and crosswise motions using burlap so to prevent edges digging into surface of concrete or working crown out of pavement.

H. Brooming:
1. Upon completion of burlap dragging, broom finish top surface of pavement. Use street brooms made for the purpose with split bamboo bristles or metal bristles.
    a. Broom width: 14 inches.
    b. Broom handle: At least one-half slab width.
2. In general make brooming perpendicular to centerline of paving unless otherwise shown. Prior to brooming, obtain the Engineer's approval of the direction of brooming for each area.

3. Pull broom gently over surface of pavement from edge to edge walking back and forth on bridge over pavement, holding handle almost vertical and allowing broom to drag lightly over surface without interruption, leaving slight ridges in concrete perpendicular to centerline of pavement.
4. Overlap ridging. Ridging not more than 1/8 inch in depth with corrugations of uniform character and width.
5. Complete brooming before rounding edges of pavement and joints.

I. Round joints and edges to radius shown.

J. To form flow line for gutters, trowel smooth 12-inch width of pavement adjacent to curbs unless otherwise shown.

K. Joint Work and Edging: Where there is an option of method for doing joint work, secure approval for the method elected and use only that method.
1. Perform joint work and edging when condition of concrete permits.
2. Ensure that joints are within tolerances specified and that there is no perceptible lip or depression other than rounding.
3. Prepare clean grooves rounded to 1/4-inch radius with smooth even walls.
4. Make grooves for expansion joints by forming. See requirements above for expansion joints.
5. For joints to be sealed with poured sealer, prepare grooves with dimensions as shown and within tolerance specified. For joints to be sealed with preformed elastomeric seals, leave grooves of dimensions and within tolerances shown. Provide suitable gauges for checking dimensions.
6. Where joints in surface course are sealed with cold-poured joint sealer, break bottom bond by placing polyethylene tape full width of groove, laid flat along top of preformed joint filler prior to joint sealing.
7. When using hot-poured or cold-applied joint sealer, use only equipment designed for purpose. Hand-pouring pots are prohibited. Maintain material within temperature range recommended by manufacturer. Apply sealer when air temperature is as specified. Construct so that resulting stripe is straight, neat, of uniform width and joint is filled to 1/4 inch from top surface of pavement.
8. When placing elastomeric joint seals, use equipment and methods recommended by manufacturer.

3.09 CURING:

A. Allow finished concrete to cure by one of the following methods for seven days or until concrete has developed flexural strength of 500 psi:
1. Wet burlap: Cover pavement with double thickness of thoroughly wet burlap, overlapping adjacent sheets by at least six inches. Maintain burlap in saturated state by sprinkling until it is removed. Use only clean material free from holes.
2. Waterproof paper, polyethylene sheet or white burlap-polyethylene sheet: Place material so that adjacent sheets overlap by at least 12 inches. Secure material along side and ends so as to maintain reasonably airtight seal.
3. Use approved liquid-membrane curing compounds as recommended by manufacturer, using equipment designed for purpose.

B. Obtain approval of the Engineer for the curing method elected and use only that method.

3.10 REMOVAL OF FORMS:

A. Remove forms as soon as condition of concrete permits, but in no case sooner than 12 hours after placement.

B. When the temperature is below 40F, leave forms in place for at least 48 hours or as directed.

3.11 COLD WEATHER CONSTRUCTION:

A. Whenever, by the National Weather Service forecast for the locality, the temperature may be expected to reach 50F or lower during the 24-hour period following placement concrete mix, include a Type C accelerating admixture in the concrete mix as specified in Section 03300. The accelerating admixture shall comply with AASHTO M 194, Type C, except that it shall contain not more than 500 parts per million chloride ion.

B. Place concrete when temperature conditions are as specified, unless otherwise directed. If placing of concrete is so directed, in addition to adding an accelerator heat aggregates, water or both, so that mix when laid is not less than 55F nor more than 90F. Do not exceed 140F for mixing water and 150F for aggregates.

C. As soon as concrete has hardened sufficiently to prevent marring, cover pavement surface and edges with dry burlap, building paper or other approved material and subsequent layer of at least six inches of dry hay, straw or other approved material. Maintain such protection for at least three days or until field tests indicate that concrete has attained required strength.

D. During low temperatures, install truck-mixed concrete immediately upon delivery.

E. When temperature by National Weather Service forecast will be 40F or lower during the 72-hour period following placement of concrete, do not use membrane curing compound.

3.12 HOT WEATHER CONSTRUCTION:

A. When by National Weather Service forecast, temperature will be 90F or higher during the 24-hour period following placement of concrete, cover pavement by wet-burlap method for first 24 hours, after which curing may be completed by one of the specified methods.

3.13 PROTECTION OF CONCRETE PAVEMENT:

A. Obtain approval prior to permitting use of completed pavement by public and construction traffic.

3.14 DEFICIENT PAVEMENT:

A. Where directed, remove and replace with new materials or correct concrete pavement that does not meet requirements.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Use second version of SECTION 02750 CONCRETE PAVEMENT for contracts where concrete pavement work is performed within the jurisdiction of the District of Columbia. (Use first version for contracts where concrete pavement work is performed outside the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02765

PAVEMENT MARKINGS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing pavement markings and striping.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Samples:
      a. Paint: One quart of each color.
      b. Spheres: Two pounds.
      c. Thermoplastic compound: Ten pounds of each color.
      d. Preformed plastic markings: Five each of plain and reflective, each three inches wide by one-foot long.
   2. Certification.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M249-79.
   3. USDOT/FHWA: Manual on Uniform Traffic Control Devices for Streets and Highways.
   4. Federal Test Method Standard 141.
   5. FED STD: 595.
   6. FS: TT-P-85, TT-B-1325.
   7. ASTM: D638.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver materials in factory-sealed containers plainly marked as follows:
   1. Manufacturer's name and address.
   2. Location of plant.
   3. Material.
   4. Color of material.
   5. Amount of contents.
   6. Date of manufacturer and lot number.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
   1. Traffic zone paint:
      a. Apply only when ambient air temperature is above 40F and temperature of surface to be painted is above 45F.
      b. If pavement is wet, allow surface to dry for eight hours minimum after surface appears dry.
      c. Do not apply glass spheres in strong windy conditions.
   2. Extruded thermoplastic compound:

a. Apply by extrusion at 400F minimum, 440F maximum, when air temperature is more than 35F and pavement temperature is above 50F.
b. If pavement is wet, delay application until the pavement has been exposed to at least two hours of direct sunlight after surface appears dry.

3. Preformed plastic traffic markings:
a. Apply on dry pavement when ambient temperature and temperature of pavement surface is above 60F.
b. When temperature of pavement surface is less than 60F and when approved, apply surface heating to degree necessary for application of plastic marking.

B. Protection:
1. Provide traffic protective devices and methods of protection to comply with requirements of the jurisdictional authorities.
2. Provide and maintain traffic cones, barricades, lights and other protective devices necessary to protect traffic, workmen and completed pavement marking and striping. Remove such devices when marking and striping, including painted sections of curbing and raised traffic bars, have sufficiently cured for intended use.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Traffic Zone Paint:
1. Primer: If recommended by paint manufacturer or required by jurisdictional authorities, type as recommended by paint manufacturer.
2. Paint: Traffic, FS TT-P-85, white and yellow.

B. Glass Beads: Retroreflective glass spheres, FS TT-B-1325, with the following additional gradation requirements:

US Sieve Size	Percentage Passing
40	100
50	80 - 100
80	35 - 80
100	20 - 50
200	0 - 15

C. Extruded Thermoplastic Compound: Hot-applied alkyd thermoplastic per AASHTO M249-79 and as follows:
1. Thermoplastic compound:
a. Mixture of thermoplastic resins and other substances compounded for use in traffic markings which, when extruded hot in place and cooled to ambient temperature, will produce stark white or yellow reflective marking stripe.
b. Permanently white or yellow, without blemish or discoloration, with straight, clean cut, sharply defined, parallel edges and of uniform cross section.
c. Shaped to minimize tire impact and adhere permanently to road.
d. Set to solid, non-tacky, non-slippery line of sufficient elasticity to resist cracking and chipping caused by weather and temperature changes, traffic action, as well as pavement crawl and lift in freezing weather.
e. After curing, does not react with nor deteriorate in contact with snow

removal chemicals, oil and other substances common to roadway surfaces.

f. Chemically stable and emitting no dangerous fumes.

g. Especially compounded for traffic markings, with no change in color and brightness characteristics after prolonged exposure to sunlight.

h. No breakdown or deterioration when held at plastic temperature for extended periods of time nor when repeatedly reheated to plastic temperature.

i. No change in temperature versus viscosity characteristics through repeated reheatings and from batch to batch.

2. White thermoplastic compound:

a. Pure white, free from dirt or tint after drying.

b. Maximum allowable compound deviations from magnesium oxide standard when tested by standard color difference meter, Gardner Color Difference Meter, Gardner Laboratories, Inc. Bethesda, Maryland or equal, with the following minimum requirements:

Scale	Definition	Magnesium Oxide Standardized	Sample
Rd	Reflectance	100	70 minimum
a	Redness - Greenness	0	Minus five to plus five
b	Yellowness - Blueness	0	Minus 10 to plus 10

c. The white compound pigment containing not less than six-percent titanium dioxide (TiO_2).

3. Yellow thermoplastic compound:

a. After drying, yellow, FED STD 595, Color 33538, tested in accordance with Federal Test Method Standard 141, Method 4252.

b. Pigmented binder well dispersed and free from skins, dirt, foreign objects or ingredients that will cause bleeding, staining or discoloration and consisting of mixture of non-drying synthetic resins at least one of which is solid at room temperature.

c. Total binder content of thermoplastic compound: 15-percent minimum, 35-percent maximum by weight.

d. Filler incorporated with resins or binder: White calcium carbonate with compressive strength of 5,000 psi.

D. Preformed Plastic Traffic Markings:

1. Composed of preformed plastic, smooth on top surface, undersurfaces factory-coated with pressure-sensitive adhesive coating overlaid with protective paper, polyethylene or other suitable material which remains in place until plastic is ready for application to pavement.

2. Plain or reflectorized.

3. White or yellow.

4. Composition:

a. Nonreflectorized plastic material: Consisting of basic plastic and plasticizers, 50-percent minimum by weight.

b. Reflectorized plastic material: Consisting of 40-percent minimum by weight of basic plastic and plasticizer and 30-percent minimum by weight of clear, reflective glass spheres, thoroughly and uniformly dispersed throughout plastic.

5. Pigmentation:

a. White plastic markings: Pure white, free from tint and containing not less than six-percent titanium dioxide.
b. Yellow plastic markings: Yellow, FED STD 595, Color 33538, Federal Test Method 141, Method 4252.
c. Uniform coloring throughout cross section of plastic.

6. Low-temperature stress resistance: No indication of breaking, chipping or cracking when sample of specified thickness is abruptly bent to right angle after being immersed in water at 32F for 30 minutes.
7. Resistance to wear: Endure not less than 2,500 cycles of a Taber Abraser, using CS-17 wheels under a load of 1,000 grams, when each 0.001-inch thickness of plastic is tested at 21C.
8. Tensile strength: Nonreflectorized markings not less than 1500 psi; reflectorized markings not less than 750 psi when tested in accordance with ASTM D638.
9. Bond strength: Withstand 50-pound static shear load for 15 seconds average at 21C before complete parting of bond when pair of two-inch wide strips are overlapped two inches and adhesive faces placed together.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL:

A. Layout of Work:
1. Lay out lane widths, parking spaces and crosswalks in accordance with regulations of jurisdictional authorities and as shown.

B. Letters and Symbols:
1. Unless otherwise shown or specified, apply letters, directional arrows and other pavement markings of size and configuration in accordance with referenced USDOT/FHWA Manual on Uniform Traffic Control Devices for Street and Highways.
2. Apply letters, directional arrows and other markings in color shown.

C. Width and Color of Lines for Pavement Striping:
1. Apply lines for pavement striping as follows:
a. Width:
1) Continuous centerline striping and parking space markings: Four inches.
2) Dashed lane striping: Four inches.
3) Solid crosswalk lines: Six inches.
4) Solid stop lines: Twelve inches.
b. Lines:
1) Dashed lane lines: White stripes nine feet in length separated by 15 feet of unmarked surface.
c. Color:
1) Stripes:
a) Solid centerline stripe: White or yellow as shown.
b) Lane striping, parking space marking, crosswalk and stop lines: White, unless otherwise shown.

D. Allowable Tolerances:
1. Traffic-zone paint:
a. Width of lines not to vary from specified width by more than 1/8 inch in each linear foot.
b. Lengths of skip or lane lines and unpainted surface between skip lines not to vary by more than three inches from specified length.
c. Coverage rate maximum: 100 square feet minimum and 110 square feet maximum of surface coverage per gallon of paint, yielding wet-film thickness

of 0.015 inches minimum.

d. Coverage rate of glass spheres: Ten pounds per gallon of paint minimum.

2. Extruded thermoplastic compound:
   a. Thickness of stripe: 90 to 125 mils.
   b. Rate of application of binder-sealer: Between 800 linear feet and 1,000 linear feet per gallon for four-inch wide lines. For lines of other widths, apply in proportion based on such rate.
3. Preformed plastic traffic markings:
   a. Thickness: 0.095 inch, minus 0.005 inch or plus 0.010 inch.
   b. Width: Four inches, plus-or-minus 1/8-inch per 12-inch length.
4. Painting of curbing and raised traffic bars:
   a. Wet-film thickness: 0.015 inches minimum.

3.02 APPLICATION:

A. Traffic Zone Paint:
1. Equipment:
   a. Use equipment suitable for mechanical application of paint and glass spheres.
   b. Apply paint with atomizing spray machines designed for striping to apply stripes of uniform cross section, and thickness, at specified coverage with clean-cut edges permitting easy and accurate adjustment of width and rate of application as well as immediate shutoff.
   c. Use automatic mechanical equipment designed and constructed to distribute glass spheres in uniform pattern and at prescribed coverage regardless of variation in speed of travel. Equipment may be integral part of striping machines or self-contained unit designed for attachment to striping machines, so that glass spheres will be applied immediately following application of paint. Use equipment designed and constructed to permit adjustment of coverage rate.
2. Method of application:
   a. Schedule marking and striping operations to permit paint to set and harden before roadway is opened to traffic.
   b. Allow hot laid bituminous material to cool, prior to beginning striping operations.
   c. Remove foreign matter from surfaces prior to painting.
   d. Apply pigmented binder and glass spheres, mix and thin pigmented binder in accordance with manufacturer's recommendations.
   e. Apply glass spheres uniformly, immediately following application of paint. Do not premix paint and spheres.
   f. Apply pavement markings accurately with straight, clean-cut, sharply defined parallel edges and of uniform cross section.
   g. Clean striping machines as often as necessary to ensure application of markings of specified quality and physical requirements.

B. Extruded Thermoplastic Compound:
1. Equipment:
   a. Master kettle:
      1) Minimum capacity: 800 pounds of melted compound.
      2) Double oil jacket.
      3) Thermostatic controls.
      4) Approved heating device.
      5) Temperature gauges for oil and compound.
      6) Integrally mounted chopping device to chop and drop solid compound into kettle.

b. Liner:
   1) Use liners with self-contained heat source, such as propane heater, capable of maintaining compound at drawing temperature of not less than 420F as well as radiant heater installed over die for same purpose.
   2) For installation of crosswalk lines, stop lines and solid center lines, use liner with capacity of approximately 150 pounds and automatic sphere dispenser capable of distributing reflective spheres on surface of line while still plastic.
   3) For centerline and lane line installation, use mobile unit equipped to automatically install dashed lines in combinations of line and skip up to 40 feet and for application of reflective spheres as specified for smaller liner.
   4) Provide for varying die widths in liner to produce specified line widths, including shaping die cutoff device to provide clean, square ends at beginnings and ends of lines.

2. Application of binder-sealer:
   a. Before applying binder-sealer or thermoplastic compound, prepare roadway surface by buffing and cleaning or other appropriate method.
   b. Where thermoplastic stripe is to be installed, spray surfaces with binder sealer consisting of two parts epoxy and one-part hardener-catalyst immediately prior to installation of compound.
   c. Mix binder-sealer fresh each day. Do not premix.
3. Application of thermoplastic compound:
   a. Apply compound in colors shown and at locations shown.
   b. Do not use pans and aprons to control width of lines.
   c. Use equipment including extrusion dies capable of maintaining compound at specified extrusion temperature and density and capable of producing stripe of specified width.
4. Application of glass spheres:
   a. Perform reflectorizing of thermoplastic compound by immediate application of glass spheres to specified density.
   b. Perform reflectorizing so that completed line registers not less than 55 on Hunter Nite Visibility Meter.

C. Preformed Plastic Traffic Markings:
1. Prepare roadway surface by removing dirt, dust, oily substances and other foreign matter before installing plastic markings.
2. Do not install plastic marking on wet or damp pavement.
3. Make installations in neat, workmanlike manner with ends and edges of successive strips of material even.
4. Position center and lane markings using chalk as guides.
5. Installation on sheet-asphalt surfaces:
   a. When plastic markings are to be installed on new sheet-asphalt surfaces, install while asphalt is still hot and immediately before final rolling is performed.
   b. As part of final rolling operation, position and embed plastic marking into surface.
   c. To install plastic markings on existing sheet asphalt, accurately locate and press marking into place and obtain final bond by at least two longitudinal passes of ten-ton roller.
6. Installation on asphaltic-concrete surfaces:
   a. Install as specified for sheet-asphalt surfaces except apply prime coat recommended by manufacturer of plastic markings to pavement surface prior to installation of markings.
7. Installation on portland-cement concrete pavement:

a. Seal surface of concrete pavement with quick-setting primer to reduce capillary action and improve bond between marking and pavement surface.
b. Otherwise install as specified for sheet-asphalt pavement.

D. Painting of Curbing and Raised Traffic Bars:
1. Paint curbing and raised traffic bars with traffic-zone paint.
2. Clean surfaces to be painted of dirt, dust, laitance, oil or other foreign substances.
3. Allow 14 days minimum after installation of portland-cement concrete before painting.
4. Curbing:
a. Paint top and front of curbing in locations shown with one coat of nonreflectorized traffic-zone paint as specified.
5. Raised traffic bars:
a. Paint surfaces, except bottom of raised traffic bars with one coat of white traffic-zone paint and apply glass spheres before paint has hardened.
b. Apply paint and glass spheres as specified.

END OF SECTION

SECTION 02772

CURBS, GUTTERS AND WALKS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing curbs, gutters, curb and gutters and walks. *1

B. This section specifies providing walks, curbs, gutters, curb and gutters, coping curbs and integral curbs. *2

C. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Base course for pavements: Section 02725.
3. Concrete pavement: Section 02750.
4. Concrete reinforcement: Section 03200.
5. Cast-in-place structural concrete: Section 03300.
6. Granite: Section 04415.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Documentation:
a. Where stone curb is provided by street or highway jurisdiction, submit bill of stone curb materials prior to picking up materials at designated storage facility and transporting to site.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: C979.

1.04 PRODUCT DELIVERY AND HANDLING:

A. Handle stone so as to maintain curb intact with exposed faces unmarred.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Concrete: Section 02750 and as specified in this section.

B. Carbon Black:
1. Emulsified: At least 25 percent by weight standard carbon-gas black colloidally dispersed in liquid medium so that when one part of product is stirred into ten parts of water, resulting liquid, after standing undisturbed for 72 hours, is uniformly colored and contains no fillers nor other material that would adversely affect quality or appearance of concrete.
2. Powder:
a. Concrete grade carbon black, meeting the requirements of ASTM C979.

b. Carbon black powder to disperse in water without floating and to be capable of uniform dispersion in plastic concrete.

C. Joint Devices:
1. In accordance with Section 02750, with the following additional requirements:
a. Dowels: 14 inches long, 3/4-inch diameter for curb and gutter and 1/2-inch diameter for sidewalk.
b. Plates for construction joints and planes of weakness: 14-gauge galvanized sheet metal cut to section as necessary.

D. Expansion Joint Materials:
1. In accordance with Section 02750, with the following additional requirements:
a. Preformed joint filler for stone curb, 1/4-inch thick; otherwise, 1/2-inch thick, subject to specified construction requirements.

E. Granite Curb: Section 04415 and as specified in this section.

F. Polyethylene Tape: Section 02750.

2.02 MIXES:

A. Mix exposed aggregate surface course concrete comprising by volume, one part portland cement to three parts granite aggregate or gravel, crushed gravel or crushed stone aggregate as shown, with sand added to form workable mix.

B. Where concrete walks are shown to be darkened, add 1/2 pound of emulsified carbon black or 1/3 pound of carbon powder per bag of portland cement.

2.03 FABRICATION AND MANUFACTURING:

A. Fabrication of Granite Curbing:
1. Drill holes are prohibited, unless otherwise specified.
2. Straight granite curbstone:
a. Width: Eight inches plus-or-minus 1/8 inch at top surface.
b. Front face: Between 12 inches and 14 inches deep.
c. Batter: One-inch per foot to depth equal to reveal plus two inches.
d. Length: Random, three feet minimum.
3. Radius curb up to and including 100 feet: Radius to have same cross section dimensions as straight curb and cut true to radius ordered. Radius curb to be not less than three feet in length measured on arc.
4. Radius curb greater than 100 feet through 200 feet: Radius to consist of straight sections not exceeding five feet in length with the ends cut to form radial joints.
5. The top surface of curbstone to be finished with four-cut or 550-shot finish, but not both, to approximately true plane, with no projection or depression greater than 1/8 inch.
6. Front face finished same as top surface for depth of reveal plus two inches, except that sawn finish will be acceptable alternate, with no projection or depression greater than 1/8 inch. Remaining depth of front face may be rough cut with depressions or projections not exceeding 1-1/2 inches.
7. Arris line between top and face to have 1/4-inch bullnose.
8. Bottom surfaces to have no projection or depression greater than 1-1/2 inches.

9. Back surfaces to be sawn or split approximately at right angles to plane of top surface. No projection or depression greater than 1/4 inch will be allowed for a distance of four inches from top. Remaining distance to have no projection or depression greater than 1-1/2 inches. Drill holes will be permitted in back surface if they do not show in top arris line.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL:

A. Allowable Dimensional Tolerances:
   1. Concrete surfaces constructed in accordance with the following:
      a. Plus-or-minus 3/16 inch of elevation shown.
      b. Deviation: 1/8-inch maximum from steel straightedge as specified in Section 02750.

3.02 BASE:

A. Ensure that previously placed base is satisfactorily compacted and free from loose material.

B. Have base approved prior to placing forms and base covering.

C. Correct deficiencies in grade, contour and compaction.

3.03 FORMS:

A. Place forms as specified in Section 02750.

3.04 JOINT DEVICES AND CONTRACTION JOINTS:

A. General Requirements:
   1. Place joint devices and contraction joints as specified in Section 02750.
   2. Where work abuts concrete pavement, adjust spacing of joints so that joints of same type coincide with transverse joints of concrete pavement.
   3. Width of preformed expansion joint filler: Same as thickness of concrete pavement minus 3/4 inch.
   4. Concrete curb, gutter and curb and gutter:
      a. Place two dowels in each joint between eight and twelve inches apart; for curb and gutter place one of the dowels four inches from back of curb. For curb and gutter abutting concrete pavements, complete partial tie rod assemblies in slab. Place preformed expansion joint filler in single piece depressed 1/2-inch below finished surface.
      b. For curves of 100 feet radius or less, space expansion joints equally at intervals of approximately 15 feet; for radii greater than 100 feet space expansion joints at intervals of 45 feet, with contraction joints at intervals of 15 feet. Form contraction joints, with plates left in place, depressed 1/2-inch below finished surface.
      c. Where placed in curves of 100 feet radius or less, stop reinforcing steel two inches clear of expansion joints.
   5. Sidewalk:
      a. Place 1/2-inch preformed expansion joint material between sidewalks and curb where sidewalks are constructed between permanent structure and curb.
      b. Place transverse expansion joints at intervals of 45 feet. [*3]

c. Place transverse expansion joints at intervals of 45 feet, unless otherwise shown. *4

d. Provide dowels in expansion joint spaced at two-foot intervals, clearing edges of sidewalk by one foot. Where sidewalks intersect, place expansion joints in each sidewalk for full width along extension of back edges.

6. Uniform Joint Spacing: For the entire length of each straight or curved run of sidewalk or curb to be placed, lay out the work and adjust joint spacing to provide intervals of equal dimension between joints, including grooves, unless otherwise shown.

3.05 CONCRETE AND WIRE FABRIC:

A. Place concrete and wire fabric in accordance with applicable requirements of Section 02750 except that top layer of fabric over trench-cuts to clear top surface by 1-1/2 inches, plus-or-minus 1/4-inch tolerance.

B. Place pipe for weep holes through curbs for rain leaders from building downspouts where shown.

3.06 STONE CURB:

A. Excavating and backfilling in accordance with Section 02320.

B. Place no-slump concrete as setting bed.

C. Ram stone curb into proper position in setting bed and set to line and grade.

D. Where stone curb ties into existing curb, align exposed abutting surfaces.

E. Place preformed expansion joint filler at each joint.

3.07 FINISHING CONCRETE CURB, GUTTER AND CURB AND GUTTER:

A. Remove curb and face forms as soon as condition of concrete permits and perform finishing work on exposed surfaces.

B. Finish face edge of curb to one-inch radius. Finish other edges to 1/4-inch radius.

C. Provide steel troweled finish followed by brushing with fine-hair brush.

D. Remove other forms when condition of concrete permits, but no sooner than 12 hours after placing. Rub surfaces with carborundum stone where necessary.

3.08 FINISHING SIDEWALK:

A. Work on Authority Property:

1. Strike off and screed top surfaces so that resulting surface is smooth and within specified tolerances.
2. As soon as condition of work permits, perform joint work, edging and marking.
3. Finish edges to 1/4-inch radius.
4. Scoring pattern: Unless otherwise shown, as follows:
   a. Expansion joints: Install on 45-foot centers. For the entire length of each straight or curved run of sidewalk to be placed, layout the work and adjust joint spacing to provide intervals of equal dimension between joints, including grooves, unless otherwise shown.

b. Contraction joints: Make transverse grooves 1/3 depth of the concrete at approximately nine-foot equal intervals between expansion joints perpendicular to longitudinal grooves.
c. Control joints: Make transverse grooves 1/2-inch deep at approximately three foot equal intervals between contraction joints perpendicular to longitudinal grooves.
d. Make longitudinal grooves 1/2-inch deep at approximately three foot equal intervals between and parallel to sides of sidewalk.

5. Finish surface with final light broom finish with fine-hair broom.
6. Construct wheel chair ramps at locations shown.
7. Remove forms when condition of concrete permit, but no sooner than 12 hours after placement. Rub surfaces with carborundum stone where necessary.

B. Non-Authority Work:
1. In accordance with codes and regulations of the jurisdictional authorities.

3.09 CURING:

A. In accordance with Section 02750, except that liquid membrane curing compounds not to be used on curb of curb and gutter when temperatures tend to go lower than 40F within 24 hours after application.

B. Do not use liquid membrane curing compounds on exposed aggregate concrete or darkened concrete surfaces.

3.10 SEALING JOINTS:

A. Immediately prior to sealing joints, place polyethylene tape width of groove flat on preformed expansion joint filler.

B. Seal expansion joints in concrete curb, gutter and curb and gutter with poured joint sealer in conformance with Section 02750. Do not seal expansion joints in sidewalk and stone curb.

3.11 HIGH EARLY STRENGTH CONCRETE:

A. Use high-early-strength concrete in accordance with Section 02750 when approved.

3.12 CORES:

A. Where directed, provide test cores in accordance with Section 02750.

3.13 PROTECTION OF THE WORK:

A. Protect new work in accordance with Section 02750.

3.14 DEFICIENT WORK:

A. Remove and replace with new materials or correct as directed work which does not meet specified requirements.

3.15 INTEGRAL CURBS: [*5]

A. Pour integral curbs with the pavement slab.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Use first version of 1.01 A. for contracts where curb, gutter and walk work is performed outside the jurisdiction of Alexandria, Virginia.

***2**. Use second version of 1.01 B. modification for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

***3**. Use first version of 3.04 A.5.b. for contracts where curb, gutter and walk work is performed outside the jurisdiction of Alexandria, Virginia.

***4**. Use second version of 3.04 A.5.c. modification for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

***5**. Add Article 3.15 including A. for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

END OF SECTION

SECTION 02820

FENCING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing chain-link fencing, gates and fan guards.

B. Related Work Specified Elsewhere:
1. Cast-in-place Structural Concrete: Section 03300.
2. Grounding: Section 16060.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
a. Manufacturer's product data and installation instructions for fence, posts, fabric, gates, hardware and accessories.
b. Site plan with fence showing locations of bracing, fan guards, gates, ground rods, depression closures and other special fence construction.
c. Details of gates, depression closures and other special construction showing fabrication and installation.
d. Details for installation of accessories.
2. Samples:
a. Chain link fabric: One of each width and type, each 24 inches long.
b. Posts, railing, braces, gate frames: One of each size and type, each 24 inches long.
c. Truss rod and turnbuckle: One each.
d. Tension wire: One, 24 inches long.
e. Barbed wire: One, 24 inches long.
f. Tension bar: One, 24 inches long.
g. Gate corner assembly: One.
h. Fabric ties: Four each.
i. Rail and brace ends and post caps: Two each.
j. Barbed wire extension arms: One each.
k. Other materials and accessories: One each.
3. Certification.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: D1.1.
3. MS: MIL-P-21035.
4. FS: FF-T-791, RR-F-191/2D, RR-F-191/3D, RR-F-191/4D.
5. ASTM: A121, A392, A413/A413M-01, C1107/C1107M-07a, F668.

1.04 JOB CONDITIONS:

A. Right of Access to Adjacent Private Property: As shown.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Fabric:
1. Steel, hot-dip galvanized after weaving, ASTM A392; Class 2 coating, two-inch mesh, No. 9 gauge wire, height shown, both top and bottom selvage twisted and barbed unless otherwise indicated on Contract Drawings. *1
2. PVC-coated steel: ASTM F668 Class 2b; two-inch mesh, 0.148-inch diameter zinc-coated steel core wire, height as shown, black color PVC; top and bottom selvages twisted and barbed, unless otherwise shown on Contract Drawings.

B. Posts, Top Rails and Braces:
1. FS RR-F-191/3D, with the following additional requirements:
   a. Posts: Class 1, Grade. Size in accordance with Table I unless otherwise shown.
   b. Top rails: Class 1, Grade A; Size SP1.
   c. Bracing: Class 1, Grade A; Size SP1.
   d. Color coating: Where PVC-coated fabric is specified, provide matching PVC color ASTM F668 Class 2b coating.

C. Accessories:
1. FS RR-F-191/4D, with the following additional requirements:
   a. Hot-dip galvanized, unless otherwise specified.
   b. Wire ties:
      1) Fabric: No. 9-gauge steel.
      2) Tension wire: No. 11-gauge steel.
   c. Tension wire: No 7-gauge Steel. *1
   d. Color coating: Where PVC-coated fabric is specified, provide matching PVC color ASTM F668 Class 2b coating.

D. Barbed Wire:
1. ASTM A121, Chain Link Fence Grade,12-1/2 gauge steel wire with 14-gauge, four-point round barbs, five inches on center.

E. Turnbuckle:
1. FS FF-T-791, Type 1, Form 1, Class 8, Size 3/8 by six, hexagonal heads, UNC threads, hot-dip galvanized. Where PVC-coated fabric is required, provide matching PVC color coating thermally fused to the galvanized steel substrate.

F. Latch:
1. Plunger bar full height of gate, to engage stop at double gates.

G. Security Chain:
1. ASTM A413, Grade 43 High Test Chain, case-hardened carbon-steel, 3/8-inch diameter; hot-dipped galvanized at exterior locations.

H. Padlock:

1. WMATA Station areas - Corbin Russwin, Catalog No. PL5090 IC high security or equal. All keys are to be turned over to the Engineer or WMATA Representative.
   a. Removable interchangeable core; with two keys, keyed and master-keyed as directed.
   b. Body: Solid extruded brass.
   c. Six-pin tumblers.
   d. Shackle: Hardened steel, zinc-plated, 2-5/8 inch shackle length, ball bearing locking heel and toe.
2. WMATA Track & Line chain-link fence gates areas - Master Lock #5KA, Key A389 with two keys. All keys are to be turned over to the Engineer or WMATA Representative.

I. Concrete: Section 03300, Class 3500, air-entrained

J. Grout: Non-shrink, in accordance with ASTM C1107.

K. High Zinc-Dust Content Paint: MS MIL-P-21035.

2.02 SWING-TYPE GATES:

A. Provide swing-type gates, size as indicated on the Contract Drawings, complete with latches, stops (if required by the manufacturer), keepers, hinges and three strands of above the fabric (if shown on the Contract Drawings).

B. Conform to Federal Specifications RR-F-191/2D, Single Swing Type I, Double Swing Type II, and as follows:

1. Hot-dipped galvanized.
2. Fabrication:
   a. Fabricate gate perimeter frame from Class 1, Size SP2 pipe per Federal Standard RR-F-191/3D.
   b. Fabric: Same fabric as used on the fence. Attach fabric securely to the gate frame at intervals not exceeding 15 inches.
   c. Barbed wire: As specified in 2.1. D above.
   d. Fan Guard: Materials and fabrication as specified for fencing.
3. Hardware:
   a. Hinges: Two or more galvanized steel or malleable iron, to suit the gate size: non-lift type, offset to permit 180 degrees opening.
   b. Latch: Galvanized steel or malleable iron, combination type with provision for padlock.
   c. Gate stops and center rest: Manufacturers' standard.

2.03 CANTILEVERED SLIDE GATE:

A. Conform to Federal Specification RR-F-192/2D, Type III.

B. Barbed Wire: As specified in 2.01 D. above.

PART 3 - EXECUTION

3.01 FENCE INSTALLATION:

A. Perform necessary clearing, grubbing, excavation and filling to provide clear line-of-fence runs.

B. Set posts in concrete footings, sized as shown. All end, corner, pull and intermediate posts are to be embedded a minimum of 3 foot below final grade. Footing depth shall be a minimum of 3 feet 6 inches.

C. Extend concrete to two inches above ground line at posts and slope to drain away from posts. Form top 12 inches of footing, with remainder poured against excavated hole.

D. Space posts at 10 feet maximum and eight feet minimum on centers. Place additional posts at each abrupt change in grade.

E. Where rock is encountered, drill holes two inches deeper than depth shown and two inches greater than outside diameter of post. After post is placed as shown and specified, and supported, fill remaining void with one-to-three grout mixture of cement and sand.

F. Where fence is located on concrete structure, weld post to base plate, thickness and size as shown on Contract Drawings. Erect fence post truly vertical, where necessary using shims of approved alloy. Secure to structure with anchor bolts; number, diameter and length as shown on Contract Drawings. Fill void under base plate with non-shrink grout. Bolts, base plate and weld to be hot-dipped galvanized.

G. Space pull posts at approximately 500-foot intervals for straight runs and at each vertical angle point. Install corner posts at each horizontal angle point. Provide corner, end and pull posts with horizontal braces and tie rods on each side of posts extending to and connecting to adjacent line posts.

H. After posts are installed and grout has set, install top rail or tension wire and securely anchor at ends and to line posts before hanging fabric.

I. Secure ends of fabric by tension bars threaded through loops in fabric and secured to posts by bands with bolts and nuts or other approved devices.

J. Attach fabric outside framing system, away from Authority property. Stretch fabric by securing one end and applying sufficient tension by mechanical fence stretchers. Fasten fabric to line posts, tension wire and top railing with tie wires at spacing shown.

K. Hold bottom of fabric as uniformly as possible to, but in no case to exceed, two inches above finished grade.

L. Provide barbed wire where shown. Install support arms at 45 degrees upward and outward from Authority property; extend corner, gate and end posts as shown. Stretch barbed wire to remove kinks and sags and secure to bracket arms, using tension bands for attachment to posts.

M. Install gates, gate stops and fan guards as shown.

N. Set gate stops in concrete accurately so that plunger can be fully engaged.

O. Furnish one chain with one padlock for each gate.

P. Grounding: Section 16060.

3.02 GATE INSTALLATION

A. Install gates plumb, level and secure for full opening without interference. Install ground-set items in concrete for anchorage, as detailed on the Contract Drawings. Adjust the hardware for smooth operation and lubricate where necessary.

B. Attach barbed wire as shown on the Contract Drawings.

3.03 DEFECTIVE WORK:

A. Remove and replace fencing which is improperly located and is not true to line and grade, and posts which are not plumb.

B. Repair damaged galvanizing by thoroughly wire brushing damaged area to remove loose and cracked zinc coating, and paint with two coats of high zinc-dust content paint. Allow first coat to dry thoroughly before applying second coat.

PART 4 -MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement of work specified in this Section will be made in the following manner:
1. No separate measurement.

4.02 PAYMENT

A. Compensation for work specified in this Section will be made in the following manner:
1. Included in the price of the work of which it is a part.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES

1. Please verify that Standard Drawings conform to the revised Specifications for Section 02820; particularly that Utility Standard Drawing ST-U-34 contains Note 8 stating that fabric on Type A & A-1 fences less than 72 inches high have both top & bottom selvages knuckled, and that Note 8 is referenced on applicable section of CHART; and contains notes to Details 2 & 3 indicating maximum height of bottom tension wire above grade is 6 inches.

END OF SECTION

SECTION 02845

TRAFFIC CONTROL DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing vehicular traffic barriers and raised concrete traffic bars.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Certification:
      a. Certificates from guardrail element manufacturer and pressure preservative-treatment plant stating that materials furnished meet specified requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AWPA: C1, P8.
   3. AASHTO: T68.
   4. ASTM: A36, A123, A153, A307.
   5. FS: TT-P-641.

B. Allowable Dimensional Tolerances:
   1. Steel guardrail elements fabricated to width and depth tolerance of minus 1/8 inch.
   2. Dimensions of concrete posts and raised concrete traffic bars: Plus-or-minus 1/8 inch of dimensions shown.
   3. Dimensions of timber posts and bracket blocks: Plus-or-minus 1/2 inch of dimensions shown.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Guardrail:
   1. Steel posts and brackets:
      a. Structural steel: ASTM A36.
   2. Wood posts and bracket blocks:
      a. Number 1 Dense SR southern pine, minimum stress-grade 1400f.
      b. Well-seasoned, sound and free from splits, cracks and other defects.
      c. Pressure treated in accordance with AWPA Standard C1 using pentachlorophenol preservative in light petroleum solvent conforming to AWPA Standard P8.
   3. Concrete posts:
      a. Concrete reinforcement: Section 03200.
      b. Concrete: Section 03300 and 03400.
   4. Rail elements and terminal sections:
      a. Rail elements and terminal sections fabricated from open-hearth or electric-furnace steel of thickness shown. Sheet shaped into beam with longitudinal corrugations forming section 12 inches minimum width and three inches minimum depth.

b. Fabrication:
   1) Edges of rail element straight and smooth.
   2) Steel sheet subject to standard mill tolerances for gauge.
c. For steel-beam type guardrail installed on curves having radius of more than 20 feet and less than 150 feet: Rail elements convex or concave as shown.
d. Elongation of two-inch specimen of sheet steel used for rail elements: 12-percent minimum when tested in tension in accordance with AASHTO T68.
e. Comply with the following:
   1) Tensile strength of specimen of full size of rail element, including a splice at center of specimen: 70,000-psi minimum.
   2) Post connections to withstand 5,000-pound side pull in both directions.
   3) Section of rail with traffic face up, freely supported at both ends of 12-foot span, to support concentrated load of 2,000 pounds at center of span with maximum deflection of two inches.
f. Rail elements and terminal pieces hot-dip galvanized after fabrication.

5. Hardware:
   a. Bolts and nuts: Steel, ASTM A307, Grade A.
   b. Post and splice bolts machined, button-head, shoulder bolts with roll threads, Class 2A fit before galvanizing. Shoulder or neck to have an oval shape as shown. Hexagon nuts for rail connections to be machined American Standard heavy-type with recess to accommodate shoulder on bolts.
   c. Bolts and nuts for offset steel brackets: American Standard heavy-type.
   d. Plate washers fabricated from steel conforming to requirements specified for rail elements and terminal connections.
   e. Hot-dip galvanized after fabrication.
6. Galvanizing:
   a. Steel posts, post anchors, brackets, rail elements and terminal sections hot-dip galvanized after fabrication in accordance with ASTM A123.
   b. Hardware hot-dip galvanized after fabrication in accordance with ASTM A153. Zinc coating: Two ounces per square foot minimum.
   c. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.
7. Primer coating: FS TT-P-641.
8. Non-shrink grout: Section 03300, shrinkage compensating.
9. Welding: Section 05120.

B. Raised Traffic Bars:
1. Formwork: Section 03100 or 03400.
2. Reinforcing steel: Section 03200.
3. Concrete: Section 03300, Class 3000, air-entrained.
4. Portland-cement grout: Section 03300.
5. Adhesive for attaching traffic bars to pavement: Polyvinyl acetate or asphaltic emulsion. If asphaltic emulsion is used, do not use clay or similar substances as emulsifying agents. Consistency of adhesive suitable for heavy trowel application at prevailing ambient temperature.
6. Anchor pins: Section 03200, concrete reinforcing rods.

2.02 FABRICATION AND MANUFACTURE:

A. Steel Posts, Brackets and Post Anchors:
1. Cut ends square. Punch or drill posts and brackets as shown.
2. After being cut to length and punched or drilled, hot-dip galvanize posts and brackets separately before bolting.
3. On end steel posts and adjacent posts weld steel channel anchor, 15.3 pounds per linear foot and one-foot three-inches long minimum.

a. Weld anchors to posts and hot-dip galvanize.
b. Welding: Section 05120.

4. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.

B. Wood Posts and Bracket Blocks:
1. Cut ends square. Drill posts and bracket blocks as shown.
2. After cutting to length and drilling, saturate cut ends and holes with same preservative as that used for pressure treatment.

C. Concrete Posts:
1. Precast concrete, Class 5000, in accordance with Section 03300, eight inches square by five feet-nine inches.
2. Reinforcement as shown and in accordance with Section 03200.
3. Cure in accordance with Sections 03300 and 03400.

D. Traffic Bars:
1. Apply shop mark on each raised traffic bar with water-resistant paint showing the following:
a. Date of manufacture.
b. Identifying mark of manufacturer.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. Where posts are to be set in drilled holes, use mobile auger.

B. Where steel posts are to be driven in place, use mobile drop hammer equipped with leads and mounted on track or on crawler treads. Protect heads of posts with driving cap designed to fit section of post being driven.

3.02 POSTS IN DRILLED HOLES:

A. Drill holes plumb, accurately positioned and of diameter and depth shown.

B. Position posts in hole to alignment shown; brace in position until remainder of hole has been backfilled with excavated material or concrete as shown.

C. Place backfill in layers six inches maximum and compact in accordance with Section 02320.

D. Dispose of surplus excavated material in accordance with Section 02320.

E. In unpaved areas, carry backfill to height of two inches above surface of ground and slope to drain away from post.

F. When holes in paved areas are shown to be backfilled with excavated material, place and compact backfill to bottom of pavement. Where pavement is portland-cement concrete pavement, fill remainder of hole with concrete to surface of pavement. Where pavement surface is asphaltic concrete, stop concrete fill two inches below final grade and fill remainder of hole with asphaltic concrete of same type as existing surface. Tamp asphaltic concrete well and slope to drain away from post.

G. Where shown to be encased in concrete, compact concrete well and carry it to height of two inches above natural ground and slope to drain. Trowel finish surface.

3.03 POST DRIVEN IN PLACE:

A. Ensure that posts are plumb and located as shown. Remove and redrive posts which are not in compliance.

B. Drive steel posts before offset bracket is attached.

C. After driving, top of posts to have substantially same cross-sectional dimensions as body of posts and be free of bends and damage to galvanizing coat. Remove posts not in compliance and drive new replacement post.

D. Drive posts carefully to prevent damage to utility facilities; if such facilities are encountered, relocate posts. Repair facilities damaged by construction operations.

3.04 POST SET ON CONCRETE PAVEMENTS AND DECK SLABS:

A. Where steel-beam guardrail is installed on existing portland-cement concrete pavement or deck slabs, fabricate steel post assembly as shown. Anchor assembly to pavement or deck slab with through-bolts or four-unit expansion anchors as shown.

B. Clean pavement or deck surface area where base plate is to be installed. Set post with base plate over bolts; plumb and shim posts to proper grade and alignment with metal shims.

C. Work nonshrink grout under plate to ensure full contact of bearing area. Remove shims as soon as concrete has hardened sufficiently to support weight of post. Finish edges true and smooth.

3.05 INSTALLATION OF STEEL-BEAM GUARDRAIL:

A. Install brackets and blocks on roadway side of posts. Tighten bolts after rail elements have been attached and entire assembly adjusted to line and grade.

B. Erection of Rail Elements and Terminals Sections:
   1. Erect rail elements and terminal sections on posts and post brackets previously set to produce smooth continuous rail to line and grade shown. Install rail with double-corrugation face toward traffic.
   2. Bolt edges and center corrugation fully.
   3. Make vertical adjustment at posts by use of oversize bolt holes in posts and brackets as shown. If oversize holes do not permit sufficient adjustment, reset post until guardrail is properly aligned.
   4. After rail has been correctly aligned, tighten bolts. Check or burr threads projecting beyond nut to prevent removal.
   5. Where steel beam-type guardrail is shown anchored to bridge piers or terminating at concrete parapet walls, punch slotted bolt holes in rail elements terminating at such locations and make connections as shown. Flame-cutting is prohibited.

C. Where approved, repair damaged zinc coating by wire brushing damaged area to remove loose or cracked zinc coating and applying two coats of primer.

D. Punching, drilling, reaming, cutting or welding rail elements or terminal pieces in the field is prohibited except as approved.

3.06 INSTALLATION OF RAISED TRAFFIC BARS

A. Install raised traffic bars at locations shown.

B. Before adhesive is applied, remove dirt, dust, grease, oil and other foreign matter that would adversely affect bond of adhesive.

C. Apply adhesive to surfaces in such quantity that firm even bearing is obtained throughout entire contact area. Remove excess adhesive.

D. Where use of steel pins is shown, drill holes through pavement, before adhesive is applied.

E. After adhesive has been applied and bars properly positioned, drive steel pins in place with top of pin two inches below top of bar. Firmly press bar into adhesive, fill pin holes with portland-cement grout flush with top of bar.

F. Where traffic bars extend across pavement joints, cut bars and make open joint of same width as joint in pavement.

G. Painting: In accordance with Section 02765.

H. Installation of traffic bars which are chipped, cracked or otherwise defective is prohibited.

I. Protect completed installation until final acceptance.

3.07 FIELD QUALITY CONTROL:

A. Top of post: Plus-or-minus 1/4 inch of elevation shown.

B. Location of post: Plus-or-minus 1/4 inch of location shown.

END OF SECTION

SECTION 02890

MARKERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing markers.

B. Related Work Specified Elsewhere:
   1. Concrete reinforcement: Section 03200.
   2. Cast-in-place concrete: Section 03300.
   3. Precast Structural Concrete: Section 03400.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Product Data:
      a. Manufacturer's construction details showing materials, dimensions and profiles for each individual component.
   2. Shop Drawings:
      a. Plans, elevations and sections detailing fabrication and erection. Show anchors, reinforcements, accessories, layout, installation details, colors and finish treatments.
      b. Message list including wording and lettering layout. Include full-size details of special graphics.
      c. Setting drawings, templates and directions for installation of anchors to be installed as work in other sections.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications.
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. FS: QQ-B-654, WW-T-791.
   3. ASTM: B36, B135

B. Survey Certification:
   1. All Right-Of-Way markers shall be set by a surveyor registered in the area where the work is to be performed.
   2. The following certification statement or a similar statement is required and shall be placed on all approved Mylar sepia as-built Right-of-Way drawings:

      "I hereby certify to the best of my knowledge that the Right-Of-Way markers shown on this as-built drawing have been set in accordance with the coordinate information provided by WMATA as shown on the Contract Documents."

      _____ (seal)
      Registered Surveyor in the State of Maryland *1

      _____ (seal)
      Registered Surveyor in the Commonwealth of Virginia *1

      _____ (seal)
      Registered Surveyor in the District of Columbia *1

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Precast Concrete: Section 03400.

B. Concrete: Section 03300, Class 3500, air-entrained.

C. Concrete Reinforcement: Section 03200.

D. Bronze Discs:
1. 3 ½ inch diameter domed survey marker forged from sold unleaded bronze in accordance with ASTM B98-98 with a classic 3 inch long and 5/8 inch diameter split-style tapered stem designed for use in concrete or rock (the Corp of Engineers Type 1 disc). Like or equivalent to the Berstsen C-1 Bronze 3 ½ inch domed marker #C35DB.
2. Refer to Standard Drawings ST-C-3 and ST-C-19 for additional details on bronze discs and installation.

E. Epoxy Hilti

2.02 FABRICATION AND MANUFACTURE:

A. Markers and Monuments:
1. Legend:
   a. Apply legend shown for various markers and monuments using characters of size and type shown. Clearly indicate use.
2. Bronze disc markers:
   a. Bronze discs as specified with imprinted or stamped legend.
3. Precast-concrete markers and monuments:
   a. Four inches square by length shown, with 1/2-inch chamfered edges.
   b. Precast concrete.
   c. One 29-inch long, No. 4 steel-reinforcing bar centered in casting.
   d. With lettering, when shown, incised v-shaped, 1/4-inch wide and 3/16-inch in depth.

PART 3 - EXECUTION

3.01 BRONZE DISCS FOR MARKERS AND MONUMENTS:

A. Except as shown, form discs into convex shape 3/16 inch in depth with edges free from burrs and blemishes.

B. Press legend into the upper surface of disc so that surface is not raised. Ensure that legend conforms to that shown for markers and monuments.

C. Do not place letters closer than 1/8 inch to outer rim of marker. Letters in outer ring of legend, 1/2-inch high; medium-sized letters, 7/32-inch high. Place letters along radius of disc. Imprint legend symmetrically about center of disc.

D. When bronze-disc markers are set in concrete pavements and roadways, set stem in drilled hole and secure with approved epoxy cement, like or equivalent to Hilti HIT Hy 150.

E. At other locations, set bronze-disc markers into tops of markers and monuments as specified; set markers and monuments in ground at locations shown.

3.02 PRECAST-CONCRETE MARKERS AND MONUMENTS:

A. Install precast-concrete markers and monuments at locations and to elevations shown or as directed.

B. Set markers and monuments as shown. Compact bottom of excavation to prevent settlement.

END OF SECTION

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Enter jurisdictions as applicable for the project locations.

SECTION 02920

TOPSOIL, SEEDING AND SODDING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing and maintaining seeding and sodding, including grass, crownvetch and lespedeza.

B. Related Work Specified Elsewhere.
1. Site grading: Section 02320.
2. Removal and restoration of existing landscaping: Section 02205.
3. Landscaping: Section 02930.

C. Definitions:
1. UMPC: University of Maryland, College Park
2. Numerical fertilizer analysis: Three-digit number indicates nitrogen, phosphoric acid and potash percentages by weight. Thus, 3-25-25 means three-percent nitrogen, 25-percent phosphoric acid and 25-percent potash by weight.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications: Keep always available at the work site a copy of each of the cited references.
1. Codes and regulations of the jurisdictional authorities.
2. USDA-SCS.
3. UMPC: Current publication of Agronomy Mimeo #77 (Turfgrass Cultivar Recommendations for Maryland).
4. ASTM: C51.

B. Personnel Qualifications:
1. Superintendent: Use a Superintendent with previous knowledge and verifiable experience in supervising seeding and sodding work of similar size and scope. Have the Superintendent present whenever work is being performed and have the Superintendent responsible for controlling the quality of work and inspecting completed work to ensure that Contract requirements are met. The Superintendent is the primary contact person with the Engineer regarding seeding and sodding work.
2. Workers: Have the work performed only by experienced workers, who through related training and verifiable previous on-the-job experience, are familiar with the technical aspects of seeding and sodding, and with the materials and equipment used for each operation. Have each worker abide by the code of ethics or professional conduct established by the Landscape Contractors Association MD-DC-VA.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Samples and Certification:
a. Submit in accordance with Table 02920-1 and as follows:
1) Seed: Each seed bag bearing the following upon delivery:
a) Analysis tag.

b) Certification tag.
c) Maryland or Virginia State tags where applicable.

2) Inoculant: Sample packet of inoculant, viable bacteria, true to legume strain required and listing source.

3) Sod: Maryland or Virginia State-Certified, each delivery bearing a Maryland or Virginia certification tag and label as required by law.

4) Topsoil: Submit supplier's name and address and source of topsoil. Submit certified report of soil laboratory test results listing textures, pH, P and K nutrients, soluble salt, organic matter and mechanical analysis as to percentage of sand, silt and clay. Do not deliver topsoil to site until approved. Approval does not constitute final acceptance.

5) Fertilizer: Labeled with manufacturer's name and address, guaranteed analysis, including nutrient and its derived source and listing of potential acidity.

6) Limestone and acidifying agent: Labeled with manufacturer's name and address, chemical analysis, oxide content and size gradation of each used.

7) Mulch and mulch binder: Labeled with manufacturer's name and address, material components, trademark, chemical analysis, species, size, age and source.

8) Herbicide: Labeled with manufacturer's name and address and chemical analysis. Include in submittal the Material Safety Data Sheet, with copies to the Engineer and Contractor's Safety Officer.

b. Usable samples will be returned.

2. Documentation:

a. Personnel qualifications: A list of the qualifications and experience of the workers, and qualifications and experience of the Superintendent, as attested by knowledge and experience in supervising contracts of similar size and scope in the past.

b. Soil tests for crownvetch and lespedeza areas: Submit certified report of soil tests *made by a* local state agricultural experiment station or agricultural laboratory recommended by U.S. Department of Agriculture. Test for pH, P and K nutrients, soluble salt, organic matter and mechanical analysis as to percentage of sand, silt and clay; and include recommended quantities of soil amendments to be added to produce the target pH value and to produce optimal growing conditions for the target crop.

c. Furnish one test for each 500 square feet of each crownvetch and lespedeza planting area, and not less than one test for each area.

d. Equipment list: A list of the equipment anticipated for use, including the make and model, year manufactured.

1.04 PRODUCT INSPECTION, DELIVERY, STORAGE AND HANDLING:

A. General: Materials and supplies are subject to inspection and sampling for testing. Allow no seed, sod, fertilizer, straw or other agronomic materials or supplies on site other than those for the project

B. Seed: Deliver with labels and tags.

C. Inoculants: Store inoculant containers below 70F until used. Keep containers sealed until contents are used in their entirety. Use inoculants before expiration date shown on packet. Using inoculants exposed to temperatures of 70F or greater is prohibited.

D. Sod: Deliver sod with labels and tags.
   1. Deliver sod to job within 24 hours after being cut; place sod within 36 hours after being cut.
   2. Prior to and after delivery during wet weather, allow sod to dry to the extent that will prevent tearing during handling and laying. During dry weather, water sod to ensure its vitality and prevent dropping of the soil in handling.

E. Topsoil: During hauling operations, keep walkway and roadway surfaces clean. Promptly remove fallen material.

1.05 JOB CONDITIONS:

A. Conduct seeding and sodding only under favorable seasonal conditions throughout the period of the Contract as determined by the Engineer. Install no work during adverse weather or during periods when soil conditions are unfavorable as determined by the Engineer. Do not plant or lay sod during freezing weather, when planting area is muddy or frozen, nor when sod is frozen.

B. Protection: During progress of operations, protect walls, walks, curbs, benches, established lawn areas, plant material, and other site improvements by adequate means acceptable to the Engineer.
   1. Weight Restrictions: Do not overload entrance paving, sidewalks and curbs.
   2. Pollution: Take necessary and adequate measures to prevent soil erosion, air pollution and water pollution by the materials and equipment used during construction.
   3. Repairs: If damage by the Contractor should occur, it is the Contractor's responsibility to repair or replace per the Engineer's direction, as acceptable to concerned parties, and at no additional cost to the Authority. Perform work so that damaged areas make smooth, satisfactory, and imperceptible transitions to existing adjacent work. Use materials and methods conforming to current standards for the area damaged, matching adjacent materials in appearance, and meeting approval of jurisdictional authorities and the Engineer.

C. If, at any time, the Engineer determines that work is unsatisfactory or being conducted in an unsafe manner, immediately cease such work activities upon notification.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Seed: Free of quack grass, timothy, bentgrass, clover, dock, annual bluegrass, cheat, chess, chickweed, crabgrass, plantain, black medic and, except where specified in Table 02920-2, Canada Bluegrass. Kentucky Bluegrass and red fescue free of tall fescue.
   1. Grass Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing; listed as Proven Cultivars in the latest Agronomy Mimeo #77 (Turfgrass Cultivar Recommendations for Maryland)*, published by UMPC*; and as specified in Table 02920-2 below.
   2. Crownvetch Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing. Germination portion consisting of minimum 35-percent normal sprouts, maximum 35-percent hard seed and as specified in Table 02920-4.
   3. Appalow Sericea Lespedeza Seed: Germination portion consisting of minimum 35-percent normal sprouts, maximum 35-percent hard seed and as specified in Table 02920-5.

B. Inoculant: Adaptable culture of live nitrogen-fixing bacteria true to legume strain used.

C. Sod:

1. Well-rooted Maryland or Virginia State-Certified sod, at least 18 months old. Varieties, identical to one of the following, or as approved:
   a. Seed mixture specified in Table 02920-3.
   b. Proven Cultivars in the latest Agronomy Mimeo #77, published by UMPC, certified 90-percent Turf-type Tall Fescue and 10-percent Kentucky Bluegrass.
2. Sod and attached soil free from noxious weeds such as Bermuda grass, quack grass, garlic, Johnson grass, Canada thistle and other turf weeds.
3. Mowed in production field to height of not more than 2-1/2 inches within five days prior to lifting.
4. Machine cut in sections not less than 2-1/2 feet in length nor less than 12 inches in width and to a depth equal to growth of fibrous roots, uniform soil thickness of 3/4 inch, plus-or-minus 1/4 inch. Measurement for thickness to exclude top growth and thatch.
5. Cut in sections or strips strong enough to support its own weight and retain size and shape when suspended vertically from firm grasp on upper 10 percent of section. Small, irregular or broken pieces of sod are prohibited. Sod on Beck Roll is permitted.

D. Topsoil: Weathered surface soils or natural friable loam obtained from approved sources, free of subsoil, hard fragments and stones larger than one-inch across greatest dimension, objectionable salts, noxious weeds and plants, debris and other materials inferior to surface soils or that would be toxic or harmful to growth; containing not less than 1.5-percent organic matter as determined by Walkley-Black Method; capable of sustaining normal, healthy growth and development of seed and sod scheduled and specified. Seed shall not be placed in topsoil which has been treated with soil sterilants until sufficient time has elapsed to allow for the dissipation of toxic materials.

1. Grading analysis:

Sieve	Minimum Percent Passing
2 inches	100
1/2 inch	90
1/4 inch	80
No. 10	70

2. Test and analysis of proposed topsoil material: Performed by local state agricultural experiment station or agricultural laboratory recommended by the U.S. Department of Agriculture, including recommendations for fertilizer and pH adjustment for target crop, and meeting the following requirements.
   a. Acidity range: pH 5.5 to pH 7.5, inclusive. When topsoil pH is not within pH 5.5 - pH 7.5, modifications to correct topsoil pH shall be made according to the recommendations of the soil test lab, or the applicable State Cooperative Agricultural Extension Service.
   b. Salinity by electrical-conductivity measurement: 500-ppm soluble salt maximum.
   c. Fertility: Rated high in natural nutrients in pounds per acre based on the standard soil test in laboratory.
   d. Texture: Classification consisting of 5-percent to 25-percent clay, 20-percent to 60-percent sand and 15-percent to 45-percent silt as determined by hydrometer or pipette method. Sand, silt and clay as defined by USDA-SCS.

E. Fertilizer:
1. For grass seeded and sodded areas: Commercial fertilizer of standard quality, recommended by approved soil test report; 10-22-22.
2. For crownvetch seeded areas: Use both of the following:
a. Commercial fertilizer of standard quality; 0-20-20 or 3-25-25.
b. Blue Chip Nitroform, slow-release nitrogen, granular form, of standard quality; 38-0-0.
3. For appalow-sericea-lespedeza seeded areas: Commercial fertilizer of standard quality, recommended by approved soil test report; 10-22-22.

F. Limestone: ASTM C51, Dolomitic, Agricultural Grade.
1. Capable of neutralizing soil acidity and containing not less than 85 percent calcium and magnesium carbonates
2. Sieve analysis: 95-percent passing No. Eight sieve and 40-percent passing a No. 100 sieve. For hydroseeding, use pulverized limestone.
3. Containers labeled to show chemicals.

G. Acidifying Agent: As approved per soil analysis recommendations and seeding method.

H. Mulch:
1. Wood-cellulose fiber: Containing no growth or germination-inhibiting factors and dyed green.
a. Properties:
1) Fiber length: Approximately 3/8 inch.
2) Diameter: Approximately 1/32 inch.
3) Acidity range: pH 4.0 to 8.5, inclusive.
4) Ash content: 1.6-percent maximum.
5) Water-holding capacity: 90-percent minimum.
b. Packaging: Furnish fibers air-dry in packages not exceeding 50 pounds gross, with net weight shown on package.
c. Source: Conwed Hydro Mulch by Conwed Corp., St. Paul, MN 55101 or equal.
2. Straw: Wheat, barley, oat or rye straw, threshed, air-dried and free from Canada thistle, dock, Johnson grass and other foreign matter.
3. Mulch blanket: Knitted construction of biodegradable yarn with uniform openings, Gulf States Paper Corporation, Tuscaloosa, AL 35401 or equal.
a. 150-foot lengths or greater.
b. U-shaped staples: As standard with mulch-blanket manufacturer.

I. Mulch Binders: Non-asphaltic only.
1. Synthetic binder for use with the following:
a. Wood-cellulose fiber: Terra Tack 1 by Grass Growers, Plainfield, NJ 07061; Soil-Gard by Alco Chemical Company, Philadelphia, PA 1913, or equal.
b. Straw: Terra Tack 1 by Grass Growers, Plainfield, NJ 07061 or equal.
2. Biodegradable netting for use with straw: Conwed Erosion Control Netting by Conwed Corporation, St. Paul, MN 55101 or equal.

J. Herbicides:
1. Broadleaf weed control: Trimec by P.B.I. Gordon Corporation, Kansas City, KS 66118 or equal.
2. Pre-emergent crabgrass control: Balan by Elanco Products Company, Division of Eli Lilly Corporation, Indianapolis, IN 46206 or equal.
3. Post-emergent crabgrass control: A.M.A., D.S.M.A., M.A.M.A. or Calcium Methyl Arsenate by W.A. Cleary Company, Somerset, NJ 08873 or equal.
4. Perennial bunch-grass control: Round-up by Monsanto Agricultural Products Company, Wilmington, DE 19810 or equal.

K. Stakes (for pegging sod): Wood or other biodegradable stakes suitable for the purpose, measuring 1/2-inch by one-inch by 12 inches.

L. Water: Potable.

2.02 SEED MIXTURES:

A. Grass Seed: Tables 02920-2 and 02920-3.

B. Crownvetch Seed: Table 02920-4.

C. Lespedeza Seed: Table 02920-5.

D. Hydroseeding Crownvetch and Lespedeza Seed: Tables 02920-6 and 02920-7.

2.03 EQUIPMENT:

A. Dry-Type Seeder: Brillion seeder, drill seeder or other approved mechanical seeder.

B. Spraying Equipment for Hydroseeding: Use water tank equipped with liquid-level gauge calibrated in increments not larger than 50 gallons over entire range of tank capacity with gauge visible to nozzle operator. Use tank equipped with agitation system capable of maintaining solids in complete suspension until used.

PART 3 - EXECUTION

3.01 PLACING TOPSOIL:

A. After completion of construction work in the area, prepare surface of subsoil. Finish to lines shown and parallel to proposed finished grade, as approved. Remove rocks and other foreign materials 1-1/2 inches or greater in any dimension. Immediately prior to covering with topsoil, loosen prepared subsoil surface to a minimum depth of four inches. Leave no depressions.

B. Place and spread topsoil over areas to be seeded and sodded except areas to receive crownvetch or lespedeza (unless Contract Drawings require 2:1 or greater slopes to be sodded or seeded), to depth which will produce four-inch depth after natural settlement and will conform to finish lines, grades and elevations.

C. When placing topsoil on slopes, work topsoil into subsoil to minimum depth of four inches to eliminate slip-plane between the two materials. Leave topsoil at surface to ensure germination of seed.

D. After spreading topsoil, rake up and remove large stiff clods, hard lumps, large rocks, roots, stumps, litter and other foreign matter.

E. Maintain specified depth of topsoil from time placed until specified seed or sod is established.

F. If soil or weather conditions are unsuitable, cease topsoil operations. Resume topsoil operations when proper conditions prevail.

3.02 SEEDING GRASS:

A. Dry Seeding: After placing topsoil, proceed as follows:

1. Seed bed preparation:
   a. pH adjustment: Adjust topsoil pH to raise it by applying limestone or approved acidifying agent or elemental sulfur to lower the topsoil pH at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations. Work into the top three inches of soil.
   b. Fertilizing: After acidity adjustment and within 24 hours before seeding, apply fertilizer at per-acre rate recommended by approved soil test report. Use machine spreader and lightly drag or rake fertilizer into top 1/4 inch of soil.
2. Seeding: Clean seeders as approved prior to applying seed. Apply seed mixture directly after fertilizing.
   a. Sow specified grass seed mixture from March 1 to April 30 and from August 15 to October 15. Extend or reduce specified periods as approved and as required by weather and soil conditions.
   b. Sow at minimum rate as specified in Table 02920-3.
   c. Work seed in to depth of 1/4-inch maximum.
   d. Finish as follows:
      1) Lawn areas with slopes up to 3:1: Raked surface.
      2) Roadside areas with slopes up to 3:1: Scarified surface.
      3) Slopes over 3:1: Leave surface in irregular condition with ridges running parallel to contour of slope to prevent erosion.
3. Rolling: Directly after seeding, roll lawn areas with slopes up to 3:1 using approved lawn roller, weighing 40 to 60 pounds per foot of width, unless intervening precipitation would cause such rolling to be detrimental.

B. Hydroseeding: After placing topsoil, proceed as follows:

1. Seed bed preparation:
   a. Clean hydroseeders as approved prior to coming on site.
   b. pH adjustment: Adjust soil pH by either applying limestone or approved acidifying agent or elemental sulfur at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
      1) Use only pulverized limestone to raise soil pH.
      2) Apply not more than 300 pounds of limestone for each 100 gallons of water.
      3) After applied limestone mixture has dried, work into the top three inches of soil.
   c. Apply elemental sulfur as recommended, and incorporate into top three inches of soil.
   d. After pH adjustment, again grade and dress seed beds for lawn areas to raked surface.
2. Fertilizing and seeding: After seed bed preparation, apply fertilizer-seed mixture.
   a. Apply fertilizer at per-acre rate recommended by approved soil test report.
   b. Apply seed at same rates and times specified for dry seeding.Mix seed and fertilizer together in proportions to meet required application rates.
   c. If mulching with wood-cellulose fiber on areas with slopes up to 3:1, add mulch to seed and fertilizer mixture.
3. Application method:
   a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
   b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
   c. Agitate mixtures constantly from time mixed until application to seed bed.

d. Use mixtures within eight hours after mixing.

3.03 SEEDING CROWNVETCH:

A. Seed Bed Preparation: After construction work in the area has been completed, proceed as follows:
1. Grading: Rough grade to remove large stones and roots. Remove or break up clods greater than one-foot diameter. Chisel surface to depth of four to six inches. When preparing slopes, chisel parallel to contour of slope.
2. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent or elemental sulfur at per-acre rate in Table 02920-6, except as recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
   a. Apply 2/3 of limestone when seed bed is prepared. Work this into the top six inches of soil.
   b. Apply remaining 1/3 of limestone with seed mixture.
3. Fertilizing: After acidity adjustment, apply fertilizer at per-acre rate in Table 02920-6, except as recommended by approved soil test report.
4. Hydraulic overseeding: For overseeding existing vegetation, cut existing vegetation to height of three inches and remove resultant refuse prior to overseeding.

B. Seed Preparation:
1. Inoculate crownvetch seed on day it is used.
2. Reinoculate seeds not sown within 24 hours following inoculation.

C. Hydroseeding: Clean hydroseeders as approved prior to coming on site.
1. From March 1 to October 15, sow specified crownvetch seed mixture (Table 02920-4) at a rate of 100 pounds per acre.
2. From June 1 to August 15 sow specified crownvetch seed mixture (Table 02920-4) at a rate of 100 pounds per acre, except add an additional three-percent by weight of Loehmans Weeping Lovegrass.
3. Extend or reduce specified periods as approved and as required by weather and soil conditions.
4. Bare areas: Perform application-sequence Stages I and II, specified below.
5. Existing vegetation areas (hydraulic overseeding): Perform only application-sequence Stage I, specified below. Obtain the Engineer's on-site approval on whether to use nozzle or hose for hydraulic overseeding.
6. Application method:
   a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
   b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
   c. Agitate mixtures constantly from time mixed until application to seed bed. Use mixtures within eight hours after mixing.
   d. Use inoculated crownvetch in slurry with fertilizers within one hour after mixing. Use fresh crownvetch seed and reinoculate seed whenever this requirement cannot be met.
7. Application sequence:
   a. Stage I, Table 02920-5: Load materials into water-filled tanks in proportion to tank size; agitate until smooth slurry is formed. Spray on seed bed at rates specified. Follow within two hours with Stage II.
   b. Stage II, Table 02920-6: Mulch area within two hours after completing Stage I. Use straw mulch for slopes up to 2:1. Use mulch blanket for slopes greater than 2:1. Do not use wood-cellulose fiber.

3.04 SEEDING LESPEDEZA:

A. Seed Bed Preparation: After construction work in the area has been completed, proceed as follows:
   1. Grading: Rough grade to remove large stones and roots. Remove or break up clods greater than one-foot diameter. Chisel surface to depth of four to six inches. When preparing slopes, chisel parallel to contour of slope.
   2. ph adjustment: Adjust soil pH by applying limestone or approved acidifying agent, or elemental sulfur at per-acre rate in Table 02920-6, except as recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
      a. Apply 2/3 of limestone when seed bed is prepared. Work this into the top six inches of soil.
      b. Apply remaining 1/3 of limestone with seed mixture.
   3. Fertilizing: After acidity adjustment, apply fertilizer at per-acre rate in Table 02920-6, except as recommended by approved soil test report.
   4. Hydraulic overseeding: For overseeding existing vegetation, cut existing vegetation to height of three inches and remove resultant refuse prior to overseeding.

B. Seed Preparation:
   1. Have lespedeza seed hulled, scarified and inoculated for spring sowing.
   2. Inoculate lespedeza seed on day it is used.
   3. Reinoculate seeds not sown within 24 hours following inoculation.

C. Hydroseeding: Clean hydroseeders as approved prior to coming on site.
   1. Sow specified lespedeza seed (Table 02920-5) from March 1 to April 30 and August 15 to October 31 at the rate of 90 pounds per acre.
   2. Extend or reduce specified period as approved and as required by weather and soil conditions.
   3. Bare areas: Perform application-sequence Stages I and II, specified below.
   4. Existing vegetation areas (hydraulic overseeding): Perform only application-sequence Stage I, specified below. Obtain the Engineer's on-site approval on whether to use nozzle or hose for hydraulic overseeding.
   5. Application method:
      a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
      b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
      c. Agitate mixtures constantly from time mixed until application to seed bed. Use mixtures within eight hours after mixing.
      d. Use inoculated lespedeza in slurry with fertilizers within one hour after mixing. Use fresh crownvetch seed and reinoculate seed whenever this requirement cannot be met.
   6. Application sequence:
      a. Stage I, Table 02920-5: Load materials into water-filled tanks in proportion to tank size; agitate until smooth slurry is formed. Spray on seed bed at rates specified. Follow within two hours with Stage II.
      b. Stage II, Table 02920-6: Mulch area within two hours after completing Stage I. Use straw mulch for slopes up to 2:1. Use mulch blanket for slopes greater than 2:1. Do not use wood-cellulose fiber.

3.05 MULCHING:

A. General:

1. Mulch according to the following slope limitations, except as limited for crownvetch and lespedeza.
2. Mulch within two hours after seeding as follows:
3. Immediately replace displaced mulching.

B. Slopes up to 3:1:
1. Wood-cellulose fiber:
   a. Apply at a net dry weight 1,500 pounds per acre.
   b. Apply hydraulically with seed and fertilizer at rate of 50 pounds per 100 gallons of water.
2. Straw:
   a. Methods of application:
      1) Hand spreading: 4,000 pounds per acre (100 pounds per 1,000 square feet). Cover areas uniformly to depth of not less than two inches of loose material.
      2) Blowing: Use of cutters is permitted in blowing equipment if at least 95-percent of mulch is six inches or more in length. For cut mulches applied by blowing method, achieve uniform distribution and loose in-place depth of not less than two inches.
      3) Mulch-binder application:
         a) Synthetic binder: Apply according to manufacturer's instructions.
         b) Biodegradable netting: Apply according to manufacturer's instructions.

C. Slopes 2:1 to 3:1: Straw as specified above.

D. Slopes over 2:1: Mulch blanket, applied and stapled according to manufacturer's instructions.

3.06 SODDING:

A. Sod Bed Preparation: After placing topsoil, proceed as follows:
1. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent, or elemental sulfur at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Mix into soil to a depth of four inches minimum.
2. Fertilizing: After pH adjustment, apply fertilizer at per-acre rate recommended by approved soil test report. Mix into soil to a depth of four inches minimum.
3. Compact topsoil with lawn roller or tractor roller to three inches of final compacted thickness as approved.

B. Laying Sod:
1. Lay sod between September 15 and June 1, grown from seed varieties identical to grass seed mixture in Table 02920-3, or sod which is Blue-Tag certified.
2. Extend or reduce specified period as approved and as required by weather and soil conditions.
3. When soil surface is hot or dry, wet soil to a depth of two inches, six to eight hours before sodding. Do not accept or lay dried sod.
4. Place sod by hand with butted joints and no overlapping. When Beck Roll of sod is used, lay also in accordance with the supplier's instructions.
5. Lay first row of sod in straight line. Place subsequent rows parallel to and tightly against each other. Stagger perpendicular joints to promote more uniform growth and strength. Do not stretch sod. On slopes, lay sod parallel to contour of slope.
6. Peg sod placed on slopes 2:1 or greater. Peg each strip or section of sod with at least two stakes not more than two feet apart. Drive stakes flush with top of sod so that roots are in contact with topsoil.

7. Water sod immediately to prevent excessive drying during progress of work. Sod which dries out will be rejected.
8. Roll entire area as sodding is completed in each section so that sod is without surface irregularities, such as depressions and high spots.
9. Irrigate immediately after rolling, enough to wet underside of sod and one inch of soil immediately below.

3.07 MAINTENANCE AND REPLACEMENT:

A. Maintenance: Maintain seeding, sodding and incidental work during seeding and sodding and thereafter for a period of 120 days for work performed in the spring and for 90 days of subsequent growing weather for work performed in the fall. Perform the following and other operations of care appropriate for promotion of healthy growth, so that work is in an approved condition throughout maintenance period; uniform in color, quality and coverage; and free of weeds, insects, diseases, surface damage and other imperfections:

1. Watering:
   a. First week: Perform watering daily to keep soil and sod pads continuously moist, maintaining moist topsoil to a depth of at least four inches. Water prior to heat of the day as necessary to prevent wilting or as approved.
   b. Subsequent weeks: Water seeded and sodded areas to maintain moisture in upper four inches of soil for promotion of deep root growth.
2. Mowing: Mow only when seed or sod has firmly rooted, is securely in place and has grown to height of six inches. Mow to height of three inches at first cutting. Thereafter, do not remove more than 1/3 of grass leaf at any cutting. Maintain Kentucky Bluegrass between height of two and 2-1/2 inches and tall fescue at height of three inches, unless otherwise directed.
3. Edging: Edge walks during alternate mowings.
4. Rolling: Roll to maintain uniform surface.
5. Applying herbicides: Apply in spray form. Do not apply when temperature exceeds 80F or during periods of drought. Have workers wear personal protective equipment appropriate for the submitted MSDS.
6. Clean-up: Remove rubbish and debris caused by this work. Keep site clean during maintenance period.

B. Replacing Seeding and Sodding: During maintenance period and until Final Acceptance, replace seeded and sodded areas that are dead, unhealthy, unsightly or badly impaired. Replace as soon as possible during the specified planting seasons. Make such replacements in the same manner as required for original seeding and sodding.

3.08 SUBSTANTIAL COMPLETION INSPECTION (SCI):

A. Substantial Completion Inspection will be held by the Engineer after completion of seeding and sodding to verify that the work was performed as defined in the Contract Documents.

B. The Contractor will not be held responsible or liable for damage by animals, by malicious or careless human agencies over which the Contractor has no control, by fire or storm, or by vehicular accidents by others that occur after the Substantial Completion Inspection.

3.09 FINAL ACCEPTANCE:

A. Request inspection for final acceptance at least 10 days before end of maintenance period.

B. Replace rejected seeded and sodded areas as specified so that repair or replacement plantings are rooted and established prior to final acceptance.

C. Final acceptance of crownvetch or lespedeza areas requires a minimum of nine vigorous, healthy seedlings evenly distributed per each square yard after 12 weeks of growing weather following germination.

TABLE 02920-1: MATERIALS SUBMITTAL CHART
This chart indicates minimum length of time required for the approval process before intended use and by which submittals must be made, as well as the minimum quantity for each sample. Useable samples will be returned.

ITEM	TIME	QUANTITY	COMMENT
SEED	40 days	10 pounds or 5 kilograms 5 pounds or 3 kilograms	If seed is purchased as a mixture. Per component prior to blending if Contractor blends mixture.
INOCULANT	7 days	1 packet	Keep temperature of inoculant below 70F (21C).
SOD	7 days	- -	Notification of source.
FERTILIZER	14 days	50 pounds (25 kilograms)	Provide sample of each type of fertilizer used. Unopened container.
LIMESTONE	14 days	50 pounds (25 kilograms)	As specified. Unopened container.
MULCH	7 days	10 pounds (5 kilograms) 1 unbroken bale 1 square yard (1 square meter)	Wood-cellulose fiber mulch. Straw mulch. Mulch blanket including staples.
MULCH BINDER	14 days	1 quart (1 liter) 1 square yard (1 square meter)	Synthetic binder. Biodegradable netting including staples.
TOPSOIL	28 days	25 pounds (15 kilograms)	- -
HERBICIDE	7 days	1 quart (1 liter)	Unopened container. Include MSDS
OTHER MATERIAL	7 days	As directed and as approved	- -

TABLE 02920-2: GRASS SEED FOR SEED MIXTURES			
SPECIES	**MINIMUM GUARANTEED PURITY**	**MAXIMUM WEED SEED AND OTHER CROP**	**MINIMUM GUARANTEED GERMINATION**
Certified Turf-Type Tall Fescue Festuca elatior arundinacea (Cultivars from current Agronomy Mimeo #77)	98 percent	0.2 percent	85 percent
Certified Kentucky Bluegrass Poa pratensis	95 percent	0.2 percent	85 percent

TABLE 02920-3: GRASS SEED MIXTURES
For areas with slopes up to 2:1, unless otherwise shown.
Seed Mixture: 90-percent Tall Fescue (Maryland Green-label certified cultivars from current Agronomy Mimeo #77) 10-percent Kentucky Bluegrass (Maryland Yellow-label certified cultivars from current Agronomy Mimeo #77)

TABLE 02920-4: CROWNVETCH SEED MIXTURE.				
For areas with slopes 2:1 or greater, unless otherwise shown.				
SPECIES	**PROPORTION BY WEIGHT**	**MINIMUM GUARANTEED PURITY**	**MAXIMUM WEED SEED & OTHER CROP**	**MINIMUM GUARANTEED GERMINATION**
Certified Penngift Crownvetch Coronilla varia	40 percent	99 percent	0.25 percent	70 percent
Certified Pennfine or Manhattan or Citation Perennial Ryegrass Lolium perenne	60 percent	98 percent	0.25 percent	90 percent
Loehmans Weeping				

TABLE 02920-5: LESPEDEZA SEED MIXTURE				
For areas with slopes 2:1 or greater, unless otherwise shown.				
SPECIES	**PROPORTION BY WEIGHT**	**MINIMUM GUARANTEED PURITY**	**MAXIMUM WEED SEED & OTHER CROP**	**MINIMUM GUARANTEED GERMINATION**
Certified Lespedeza Certified Appalow	44 percent	99 percent	0.25 percent	70 percent
Nurse Grass: *Certified Tall Fescue per Maryland Green-label certified cultivars from current Agronomy Mimeo #77	56 percent	98 percent	0.20 percent	85 percent

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TABLE 02920-6: MATERIALS FOR HYDROSEEDING CROWNVETCH AND LESPEDEZA STAGE I		
MATERIAL	**PER ACRE**	**PER 1,000 SQUARE FEET**
Limestone	**2 ton minimum	**100 pounds
3-25-25 fertilizer or 0-20-20 fertilizer or *10-22-22 fertilizer	600 pounds 800 pounds *1,075 pounds	15 pounds 20 pounds *25 pounds
Blue Chip Nitroform, granular, 38-0-0	200 pounds	4.5 pounds
Nurse Grass: Certified Pennfine, Citation, or Manhattan Perennial Ryegrass Seed or *Certified Tall Fescue per Table 02920-5	 60 pounds *50 pounds	 1.5 pounds *1.25 pounds
Target Crop: Blue Tag Certified Penngift Crownvetch Seed or *Certified Appalow Sericea Lespedeza	 40 pounds *40 pounds	 1 pound *1 pound
Bacterial crownvetch or lespedeza inoculant in 5-pound-size packets	Five times manufacturer's recommended rate	Five times manufacturer's recommended rate
Wood-Cellulose Fiber	435 pounds (dry weight)	10 pounds
Mulch Binder (synthetic type)	20 pounds	0.5 pounds

* Lespedeza requirements only.
**Superseded recommendation of approved soil test report

TABLE 02920-7: MATERIALS FOR HYDROSEEDING CROWNVETCH AND LESPEDEZA STAGE II		
MATERIAL	**PER ACRE**	**PER 1,000 SQUARE FEET**
Straw	4,000 pounds	100 pounds
Mulch Blanket and Staples	Use according to manufacturer's instructions	Use according to manufacturer's instructions

END OF SECTION

SECTION 03100

CONCRETE FORMWORK

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies formwork for concrete structures and other facilities.

B. Related Work Specified Elsewhere:
1. Concrete reinforcement: Section 03200.
2. Cast-in-place structural concrete: Section 03300.
3. Structural precast concrete: Section 03400.
4. Prestressed concrete: Section 03415.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ACI: 347, Publication # 4
3. Western Woods Producers Association : Western Lumber Grading Rules.
4. CE: CRD-C 572.
5. AASHTO: M153.
6. ASTM: D1056, D1149, D1692.
7. APA: HDO Plywood Exterior Grade.
8. U.S. Product Standard : PS 1

B. Responsibilities:
1. Design and construction of formwork is the responsibility of the Contractor, subject to review by the Engineer.

C. Design Criteria:
1. Design formwork for vertical loads and lateral pressures in accordance with ACI 347.
2. Design formwork system which is adequately braced and has adequate strength and stability to ensure finished concrete within the specified tolerances.
3. When necessary to maintain the specified tolerances, design camber into the formwork to compensate for anticipated deflection and creep due to the weight and pressure of the fresh concrete, prestressing forces and construction loads.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Working Drawings:
   a. Include details of form types, methods of form construction and erection, design computations and location of form joints and form ties, location and dimensions of blockouts and openings in structure, and embeds.
2. Samples:
   a. Each type of waterstop proposed for use, each one foot long: Two.
   b. Each type of premolded expansion-joint filler proposed for use, each six inches by 12 inches: Two.
   c. Proposed dovetail anchor slot, each twelve inches long: Two.
   d. Snap-off form ties: Two.

3. Certification:
   a. Manufacturer's certificates.
   b. Certified test reports of specified concrete tests.
4. Documentation:
   a. Calculations: Early form removal calculations as specified certified by a professional engineer registered in the area where the work is to be performed. Submit in advance for obtaining approval prior to form removal.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. General:
1. Wood forms:
   a. All framing lumber stress-graded.
   b. Lumber in direct contact with concrete, dressed on at least the contact side, with dressed or tongue-and-groove edges; other lumber may be dressed or rough.
   c. Where vertical board finish is shown or specified, use the following:
      1) Form board: Tongue-and-groove, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four-inch nominal width, groove S2S milled or beveled one side only and center matched with 45-degree beveled edges to produce sharp V-shaped 3/8-inch wide in concrete. Four-inch tongue-and-groove boards to be toenailed at edge or face-nailed to backer board.
      2) Smooth concrete: Tongue-and-groove, square cut unturned edges, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four inches nominal width, S2S and center-matched.
2. Plywood forms:
   a. APA grade-marked:
      1) B-B Plyform Exterior grade Group I or II for unexposed finished concrete.
   b. APA High-Density Overlay (HDO) plywood;
      1) B or better face veneer Exterior grade Group I for exposed to public view finished concrete..
   c. USPS : PS 1
3. Tubular fiber forms:
   a. Spirally constructed of laminated plies of fiber.
   b. Wall thickness as recommended by the manufacturer to meet load requirements of various uses and sizes.
   c. Outside surface wax-coated for moisture resistance.
   d. Inside surface of column forms coated with bond-breaker compound and fabricated so that finish concrete surfaces are smooth and free of spiral and seam marking.
4. Fibrous-glass reinforced plastic forms:
   a. One-piece dome system forms, fabricated of plastic reinforced with fibrous glass.
   b. Molded under heat and pressure using matched metal dies.

c. Special sizes and cross sections with thickness, reinforcement and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities.

5. Steel forms:
   a. One-piece dome system forms.
   b. Special sizes and cross sections as shown, with metal gauges, reinforcement, stiffeners and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities and concrete stain.
6. Hardboard:
   a. For concrete not exposed to public view: tempered, smooth-one-side (S1S) panels not less than 3/16-inch thick, in accordance with AHA IS 1.
7. Form ties:
   a. Factory-fabricated, snap-off metal type, of adequate design to minimize form deflection and preclude concrete spalling upon removal.
   b. Fabricated so that set-back in concrete is such that portion of tie remaining after snap-off and removal of exterior portions is at least 1-1/2 inches below concrete surface.
8. Form release agent: Chemically reactive liquid product that will not bond with, stain, or impair concrete surfaces. Follow form panel manufacturers approved product and recommendations for application. Agents containing castor oil are prohibited
9. Preformed expansion joint filler: AASHTO M153.
   a. Type I: Sponge rubber.
   b. Type II: Cork.Type III: Self-expanding cork.
10. Waterstops: PVC, CE CRD-C 572.
11. Dovetail-anchor slots: 22-gauge electrogalvanized steel, with removable felt filler.
12. Chamfer strips: Except where other sizes are shown, 3/4-inch by 3/4-inch triangular fillets milled from clear, straight-grain pine, surfaced-each-side, or extruded-vinyl tape.
13. Miscellaneous preformed strips for reveals, rustications and similar joints: Fabricated of wood, metal, plastic or other approved material formed to cross sections shown.
14. Hydraulic-cylinder well casing: Assembly of pipe, coupling and bottom end cap, of thermosetting-polymer vinylester resin reinforced with fibrous glass, with integral waterstop and anchor flange at invert slab as shown and concrete contact area surfaced with alkaline-resistant barrier, with the following additional requirements:
   a. Properties.
      1) Minimum density at 73F: 0.060 pound per cubic inch.
      2) Minimum tensile strength at 73F: 12,000 psi.
      3) Minimum compressive strength: 18,000 psi.
      4) Minimum flexural strength: 20,000 psi.
      5) Minimum flexural modulus of elasticity at 73F: 1,500,000 psi.
      6) Maximum fire-spread rate: 25.
      7) Maximum heat-distortion temperature at 264 psi: 215F.
      8) Maximum water absorption in 24 hours at 73F: 0.02 percent.
   b. Wall thickness: As shown but not less than 3/8 inch.
   c. Inside diameter: 20 inches.
   d. Pipe furnished with fewest number of joints, watertight, developing full strength of section, made true and straight, with not more than ½-inch deviation from vertical for entire length of pipe.
15. Conduit: Schedule 40, black steel pipe, butt-welded as specified in Section 15205.
16. Premolded Elastic Filler for elevator hoistways:
   a. Closed-cell neoprene:
      1) ASTM D1056, Grade SCE-45.
      2) Water absorption: No increase in weight in excess of two percent when tested in accordance with ASTM D1056 and completely immersed in water for 70 hours at room temperature.

3) Flame resistance: Self-extinguishing when tested in accordance with ASTM D1692.

4) Resistance to ozone cracking: No cracking when tested in accordance with ASTM D1149, after exposure to 100-pphm ozone in air for 100 hours at 100F with specimens under 20-percent strain.

17. Bonding adhesive: As recommended by manufacturer of premolded elastic filler.

PART 3 - EXECUTION

3.01 CONSTRUCTION AND WORKMANSHIP:

A. Concrete finishes and usage locations of various types of forms and form lining: As shown or specified.

B. Unless otherwise shown for concrete surfaces exposed to public view, use HDO Plywood in largest practicable continuous panels to produce plane, smooth surface free from grain imprint, patchmarks, and discoloration.

C. Construct adequately braced formwork so that resulting concrete surfaces conform to specified tolerances.

D. Brace forms, falsework and centering adequately to retain forms in position as shown on approved working drawings.

E. Provide mortar-tight forms of wood, plywood, fibrous-glass-reinforced plastic, steel or other approved materials which conform to shapes, lines and dimensions shown and produce smooth surface without fins and projections.

F. Where shown or directed because of lagging or form irregularity, and where concrete surfaces will not be exposed to public view, line inner form surfaces with hardboard as follows:

1. Use widest available width of hardboard.
2. Line areas less than four feet wide with single-width piece of hardboard.
3. Offset lining joints from those in backing.
4. Fasten securely to backing with galvanized or aluminum nails driven flush.

G. Forms shall be clean of any rust, molds, concrete scale..etc.

3.02 FIELD QUALITY CONTROL:

A. Allowable Tolerances:

1. Construct elements except concrete linings of tunnels to meet allowable tolerances of dimensions, elevations and positions shown and specified in Section 03300.
2. Prior to installation, test hydraulic cylinder well casing assembly hydrostatically at 60 psi pressure for two hours in the presence of the Engineer.

3.03 COATING FORMS:

A. Lightly coat form panels with chemically reactive release agent prior to initial concrete placement and before each subsequent placement.

B. Do not allow excess coating material to stand in puddles in forms nor to come into contact with concrete against which fresh concrete is to be placed.

C. Coat with release agent bolts and rods that are to be completely removed or to be free to move

3.04 EMBEDDED ITEMS:

A. Ensure that items to be embedded in concrete are free from oil and foreign matter that would weaken bond of concrete to such items.

B. Install in formwork inserts, anchors, sleeves and other items specified elsewhere. Close ends of conduits, piping and sleeves embedded in concrete with caps or plugs.

C. Install continuous dovetail-anchor slots where shown.

D. Complete tests on piping and other items before starting concrete placement.

E. Before depositing concrete, check location and support of piping, electrical conduits and other items which are to be wholly or partially embedded.

3.05 OPENINGS AND RECESSES IN CONCRETE:

A. Provide openings and recesses; place sleeves furnished by other trades.

3.06 JOINTS:

A. Unless otherwise directed, make contraction, expansion and construction joints only where shown. Where concrete will be exposed to public view, use largest practicable size sheets to minimize joints.

B. Form keyways as shown.

C. Continue reinforcing steel and wire fabric across joints unless they are shown as being free to move.

D. Make maximum distance between transverse contraction joints 50 feet or as shown, as measured along centerline of track on tangent alignment.

E. Install premolded joint filler at locations shown. Extend filler from bottom of concrete up flush to finish concrete surface or hold down below finish surface as shown.

F. Make splices in premolded filler in manner to preclude penetration of concrete between joint faces.

G. Where premolded joint filler is held below finish concrete face, install in the form a water-soaked wood strip of dimensions shown, to form, after removal, proper size slot to receive sealant compound specified in Section 07900.

3.07 WATERSTOPS:

A. Install waterstops in construction joints below grade and where shown. Use six-inch minimum width, except use nine-inch minimum width in tunnel structures, or as shown.

B. Support and protect that portion of waterstop which extends beyond bulkhead, during placing of concrete and subsequent removal of forms.

C. Position waterstops so as to clear reinforcement. Ensure that the waterstop does not get misaligned or misplaced during concreting.

D. Make field splices by heat-sealing square cut ends of waterstop using hot metal plate or thermostatically controlled electric-heating iron designed for such purpose. Join ends when material becomes molten, maintaining continuity of ribs and bulbs; allow to cool before stressing.

E. Make field splices to develop watertightness equal to that of unspliced material and tensile strength of not less than 50 percent of unspliced material. Have 90-degree splices and as many other splices as possible made in the factory.

3.08 REMOVAL OF FORMS, FALSEWORK AND CENTERING:

A. Maintain forms, falsework and centering in place until the concrete has attained minimum percentage of specified design strength in accordance with Schedule 1:

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Structural Member	Minimum Percentage of Specified Design Strength	
	Schedule 1	Schedule 2
Footings; inverts; sides of beams; slabs and girders; slabs and beams on grade	25	20
Free-standing walls, columns and piers	40	30
Cut-and-cover box structure exterior walls; retaining walls	50	30
Cut-and-cover box structure roofs	80	40
Stairways	80	60
Soffits, beams, slabs and girders; clear span between supports, under 20 feet over 20 feet	 80 90	 60 70
Tunnels, except intersecting sections	80	35
Station arches, except intersecting sections	80	40
Cantilevers	90	70

B. Early removal of forms, falsework and centering will not be allowed for concrete strength values below Schedule 2, but will be allowed for concrete strength values between Schedule 1 and Schedule 2 only after:

1. The Engineer has approved calculations showing anticipated concrete strengths at time of proposed early removal based on:
   a. Ratio of dead load over live load.
   b. Span, height and shape.
   c. Ratio of rise over span.
   d. Reshoring.
   e. Loads, resultant stresses and deformations to which concrete and reinforcing steel will be subjected at time of removal, subsequent to removal and until concrete has attained design strength.
   f. Prevailing site conditions.
2. Concrete strength attained prior to form removal has been determined by analysis of quality-assurance data in accordance with Section 03300.

C. Do not remove wood board forms within 48 hours of pouring concrete.

D. Do not alter loading conditions on concrete subsequent to removal of forms if it results in exceeding permissible stresses and deformations at attained concrete strengths.

E. The Engineer may permit early removal of concrete support without submittal of calculations prior to attainment of specified design strength if he considers such submittals to be unnecessary.

3.09 INSTALLATION OF HYDRAULIC-CYLINDER WELL CASINGS:

A. Cement bottom end cap to casing pipe with solvent cement prior to installation. Solvent cement, procedures, environmental requirements and instructions for proper cementing as recommended by pipe manufacturer.

B. Accurately position, plumb and set as shown. Separate casing, including anchor flange, two inches minimum from reinforcing steel and other metallic material.

C. Except as otherwise specified, perform excavation and backfill as specified in Section 02320. Do not jack or drive casing. Backfill excess excavation around exterior of casing with sand.

D. Recheck casing for orientation and secure immediately prior to pouring of concrete slabs in which it is to be set.

E. Deviation of alignment of centerline of casing not more than 1/2 inch from true vertical, end-to-end.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies reinforcement for concrete structures and other facilities.

B. Related Work Specified Elsewhere:
1. Concrete formwork: Section 03100.
2. Cast-in-place structural concrete: Section 03300.
3. Structural precast concrete: Section 03400.
4. Prestressed concrete: Section 03415.
5. Asphalt or bitumen fill in concrete notches at copper bonding: Section 07125.
6. Additional copper bonding work adjacent to traction power substations: Section 16060.

C. Definitions:
1. Cover: Thickness of concrete between outside surface of reinforcement and outside face of concrete.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ACI: SP-66, 318.
3. CRSI: Manual of Standard Practice; Placing Reinforcing Bars.
4. AASHTO: Standard Specifications for Highway Bridges.
5. ASTM: A82, A185, A615, A775, A706.

B. Allowable Tolerances:
1. Cut and bend reinforcing steel to conform to dimensions shown within the following tolerances:
   a. Sheared length: Plus-or-minus one inch.
   b. Depth of truss bars: Plus zero or minus 1/2 inch.
   c. Stirrups, ties and spirals: Plus-or-minus 1/2 inch.
   d. All other bends: Plus-or-minus one inch.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Detail reinforcing in accordance with ACI SP-66.
   b. Bar lists showing the individual weight of each bar, total weight of each bar size and total weight of bars on list. Base calculated weights on theoretical unit weights shown in ASTM A615, Table 1.
   c. Details showing bonding of reinforcement for stray current and cathodic protection.
2. Certification:
   a. Manufacturer's certificates.
   b. Mill tests on each heat showing chemical and physical analyses performed in accordance with ASTM A615, as modified by ACI 318.

c. Record of mill tests traceable to individual reinforcement bars supplied to the project.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship reinforcing steel in bundles limited to one size and length.

B. Tag each bundle at mill with waterproof tag showing name of mill, heat number, grade and size of bars and identifying number.

C. Protect reinforcing steel and wire fabric from damage; foreign matter such as dirt, oil and grease; and rust-causing conditions.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Reinforcing Steel Bars:
1. ASTM A615, Grade 60, modified in accordance with ACI 318.
2. ASTM A706, for all welding reinforcing bars, except for electrical bonding.
3. Epoxy Coating: ASTM A775, as shown.

B. Spiral Reinforcement: ASTM A82 or ASTM A615, Grade 60.

C. Welded Steel-Wire Fabric: ASTM A185.

D. Metal Accessories: As recommended by CRSI Manual of Standard Practice. Where concrete surfaces will be exposed to public view in finish structure, use supports with plastic-protected legs or stainless steel legs.

PART 3 - EXECUTION

3.01 CUTTING AND BENDING:

A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.

B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

3.02 BAR SUPPORTS AND SPACERS:

A. Support bars by means of bolsters or chairs with no less than minimum required by ACI SP-66.

B. Reinforcing steel in bottom of slabs resting on earth may be supported by concrete brick or mortar blocks.

C. In walls, columns, piers and abutments hold reinforcing steel in position by means of mortar blocks, bar supports or spacers wired to reinforcing steel.

D. Do not use stones, clay bricks, wood blocks or pieces of broken concrete to support reinforcing steel.

E. Do not place bars or fabricated mats on layers of fresh concrete as work progresses.

3.03 PLACING AND FASTENING:

A. Arrange and place reinforcing steel as shown.

B. Secure reinforcement positively against displacement during placing of concrete.

C. Wire or clip bars together as recommended in CRSI Placing Reinforcing Bars.

D. Maintain reinforcing steel accurately in locations shown in tops of inverts to permit arrangements of anchor bolts for rail-tie plates.

E. Before placement, ensure that reinforcement is free from dirt, mill scale, rust scale, oil, grease and other foreign matter.

3.04 SPLICING:

A. Furnish reinforcing bars in full lengths as shown on the Contract Drawings and approved shop drawings.

B. Do not splice bars unless approved in writing.

C. Make splices when authorized, in accordance with ACI 318, except make all butt splices by welding with a capacity of not less than 125 percent of minimum yield strength of bar. Mechanical connections for tensile splice shall be by cadweld only.connections for t Cadweld only. However, mechanical connection for precast prestressed structures and parking garages, when the splice is located inside the precast member, may be made by NMB Splices instead of the Cadweld, with prior approval of the Authority.

3.05 ELECTRICAL BONDING:

A. Weld steel straps to transverse end reinforcing bars and longitudinal reinforcing bars adjacent to joints between pour sections at locations shown.

B. No electrical bonding is required for epoxy coated rebars.

C. Thermit weld or cadweld stranded, bare-copper conductors to adjacent steel strips at specified end locations. Likewise, weld copper conductors to lapped, welded-wire fabric at joints in slabs at locations shown.

D. Additional copper bonding work adjacent to traction power substations: Section 16060.

E. Asphalt or bitumen fill in concrete notches at copper bonding: Section 07125.

3.06 STUDS:

A. Install welded studs in track invert slabs on top of transverse bars 10 feet on center and on first transverse bar at each end of units. Expose tops of studs and set flush with top surface of slab.

3.07 INSPECTION:

A. Placement of concrete prior to approval of reinforcement and electrical bonding work is prohibited.

3.08 CONCRETE PROTECTION FOR REINFORCEMENT (COVER):

A. Underground Box Section Structures:
   1. Invert slab:
      a. Top steel: Two inches.
      b. Bottom steel: Three inches.
   2. Roof slab:
      a. Top steel: Two inches.
      b. Bottom steel: 1-1/2 inches.
   3. Exterior walls:
      a. Outer-face steel: Three inches.
      b. Inner-face steel: 1-1/2 inches.
   4. Center walls: 1-1/2 inches.
   5. Beams, girders and columns: 1-1/2 inches.
   6. Intermediate floors, platform slabs and stairs: 3/4 inches.

B. Retaining Walls:
   1. Footing:
      a. Top steel: Two inches.
      b. Bottom steel: Three inches.
   2. Wall:
      a. Outer-face steel: Three inches.
      b. Inner-face steel: Two inches.

C. Other Underground Structures:
   1. Outer-face steel: Three inches.
   2. Inner-face steel: Two inches.
   3. Drainage slot: Two inches.
   4. Safety walk: 1-1/2 inches.
   5. Beams, girders and columns: 1-1/2 inches.
   6. Intermediate floors, platform and slabs and stairs: 3/4 inch.

D. Above-Ground Structures:
   1. Prestressed concrete bearing highway or transit loads: In accordance with AASHTO Standard Specifications for Highway Bridges.
   2. Ancillary structures including precast prestressed structures: : ACI 318.

3.09 EPOXY COATING:

A. Preparation of surface: Perform the following in order given:
   1. Clean surface contaminated with oil and grease using naptha or xylol.
   2. Remove weld slag, rust and mill scale from surfaces by wire brushing.
   3. Coat surfaces immediately with methyl-methacrylate primer.
   4. Apply coating only to surfaces which are dry and free of contaminants.

END OF SECTION

SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing portland-cement cast-in-place concrete.

B. Related Work Specified Elsewhere:
1. Concrete pavement: Section 02750.
2. Curbs, gutters and walks: Section 02772.
3. Chemical grout: Section 2415.
4. Concrete formwork: Section 03100.
5. Concrete reinforcement: Section 03200.
6. Structural precast concrete: Section 03400.
7. Prestressed concrete: Section 03415.
8. Asphalt or bitumen fill: Section 07125.
9. Copper bonding work: Section 16060.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ACI: 201.2R, 211.1, 304, 309, 318, 318.1.
3. AASHTO: M182, T26.
4. NBS: Handbook 44.
5. USBR: Concrete Manual.
6. FS: A-A-341A, HH-I-521, K-P-146.
7. ASTM: A43, A47, A48, C31, C33, C39, C40, C42, C87, C88, C94, C131, C150, C171, C172, C260, C295, C309, C311, C330, C494, C535, C586, C595, C618, C665, C685, C881, C989, C1107, C1260, D98, E328.
8. CPMB (Concrete Plant Manufacturer's Bureau): Concrete Plant Standards.

B. Testing Laboratory:
1. Furnish the services of an independent testing laboratory. Employment of an independent laboratory does not relieve the Contractor of the obligation to perform the work in accordance with requirements of the Specifications and Drawings. Submit certified results of the tests performed.
2. Furnish proof that the laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories.
3. Certify that testing equipment has been calibrated by an accredited calibration agency at not more than 12-month intervals using devices of accuracy traceable to the National Institute of Standards and Technology (NIST) or accepted values of material physical constants

C. Properties of Concrete:
1. General:
   a. Design mixes to produce concrete of proper workability, durability, strength, maximum density, minimum shrinkage and permeability.
   b. Design mixes to have minimum water content per cubic yard of concrete, cement content corresponding to appropriate water-cement ratio, largest

permissible maximum size specified of coarse aggregate available and optimum percentage of fine aggregate.

c. Use maximum size of coarse aggregate in accordance with ACI 211.1.

d. Use same brand from same source throughout the work.

e. Use aggregates from same source throughout the work.

f. Use ground-iron blast-furnace slag and fly ash from the same sources respectively throughout the work.

2. Durability:

a. Maximum water cementitious materials ratio as per ACI 318, Chapter 4 and ACI 201.2R.

b. Use a suitable combination of approved air-entraining admixture and water reducer to reduce water content and permeability of the concrete, provided such admixtures do not adversely affect other specified properties of concrete.

c. For precast prestressed parking garages -

1) The four-inch thick cast-in-place concrete overlay topping over the double tees on top level of the Parking Structure, the concrete shall attain 28 days minimum compressive strength of 7,000 psi with a water-cement ratio of 0.38 or less. The cast-in-place concrete overlay topping wash strips over the inverted tee beams on top level and wash strips over the inverted tee beams on all other levels, and all cast-in-place concrete wash areas over the double tees, the concrete shall attain 28 days minimum compressive strength of 5,000 psi with a water-cement ratio of 0.40 or less. And for all other cast-in-place concrete, the concrete shall attain 28 days minimum compressive strength with a water-cement ratio of 0.45 or less.

2) Use a calcium nitrite-based corrosion inhibitor as specified in Section 03300.2.1.T, in the cast-in-place wash strips or areas, in the cast-in-place concrete overlay topping.

3. Workability:

a. Use approved chemical admixtures as needed for workability so that concrete can be placed, consolidated, and finished without segregation or excessive bleeding.

4. Strength:

a. Design mix for each class and type of concrete of each specified strength based on overdesign factor in accordance with ASTM C94. Unless otherwise shown, working-stress method applies to structures.

b. Design each class of concrete in accordance with the following:

1) Not more than the following percentages of strength tests to have values less than specified strength:

2) Working-stress method: 20 percent.

3) Ultimate-strength method: 10 percent.

4) Prestressed structures: 10 percent.

5) Average of the following numbers of consecutive strength tests to be equal to or greater than specified strength:

a) Working-stress method: Six.

b) Ultimate-strength method: Three.Prestressed structures: Three.

c. When number of tests totals six or less, average to be in accordance with Note 21 of ASTM C94.

5. Appearance:

a. Cured concrete exposed to public view shall be uniform in color, texture and finish with no discernible form or patch marks, grain imprint, joint irregularities or discoloration. Use only manufacturer approved chemically reactive release agents on HDO plywood forms.

b. Final selection and approval for color shall be made by the Engineer.

D. Method of Proportioning:
   1. Proportion mixes as described in ACI 211.1.
   2. Approximate mixing-water and air-content requirements for mixes of different slumps and nominal maximum sizes of aggregates as specified in ACI 211.1, Table 5.3.3.
   3. Do not vary proportions of ingredients of approved mixes without written approval.

E. Demonstration Section:
   1. Before proceeding with tunnel lining, completely seal a 25-foot long demonstration section using materials and methods to be used in the work in accordance with specified requirements.

F. Ready-Mixed Concrete: ASTM C94.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Product Data: Manufacturer's literature completely describing each material, standard, test data, installation instructions and special instructions or safety precautions applicable to the materials.
      a. Samples:
         1) Concrete surface sealer: Two, each one pint.
         2) Membrane-forming curing compound: Two of each type, each one pint.
   2. Sandblast finish:
      a. Number 6 sandblast finish as specified, each 12 inches square by two inches: Two.
      b. Seal 1/2 of face of each sample with concrete surface sealer.
      c. If samples are not approved or if concrete mix is changed, submit additional samples until approved.
      d. When samples have been approved, submit details of procedures followed to produce approved surface finish including, but not limited to, the following:
         1) Size and type of nozzle.
         2) Air pressure.
         3) Distance of nozzle from surface blasted.
         4) Duration of blast.
   3. Concrete panels of each type of concrete used in the work: Two each, 18 inches square by two inches thick.
   4. Certification:
      a. Ingredients:
         1) Submit with mix design, laboratory test reports and mill or manufacturer's certificates verifying that ingredients conform to specified requirements. Use ingredients in design mix which are representative samples of materials to be used in the work.
         2) Submit test results whenever the aggregates, cement or other additives to be used in the concrete come from a different lot, source, other area of the quarry, different quarry or from other than the representative stockpile or batch from which the original material was tested and approved.
      b. In case the source, brand or characteristic properties of ingredients need to be varied during the term of the Contract, submit revised laboratory-mix report in accordance with procedures specified for original mix design.
      c. Batch tickets:

1) Before unloading at the site, submit certification or delivery ticket from concrete supplier with each batch delivered to the site bearing the following information:
   a) Name of supplier.
   b) Name of batching plant and location.
   c) Serial number of ticket.
   d) Date.
   e) Truck number.
   f) Specific job designation: Contract number and location.
   g) Volume of concrete in cubic yards.
   h) Class and type of concrete.
   i) Time loaded.
   j) Type and brand of cement.
   k) Weight of cement and fly ash or ground-iron blast-furnace slag.
   l) Maximum size of aggregates.
   m) Weights of coarse and fine aggregates.
   n) Maximum amount of water to be added and amount of water added at the site.
   o) Kind and amount of admixtures.

5. Documentation:
   a. Proposed methods for controlling concrete temperature and plans for placing concrete taking into account sun, heat, wind, ambient air temperature or other limitations of facilities that will prevent proper finishing or curing.
   b. Quality control plan for floor treatment. Submit as specified prior to installation.
   c. Quality control reports. Submit as specified after installation.
   d. Design mixes:
      1) Prior to placing concrete, submit design mixes for each class and type of concrete, certifying that proposed concrete ingredients and proportions will result in concrete mix meeting specified requirements.
      2) Include for each class and type of concrete as many mix designs as there are combinations of different ingredients or types of ingredients anticipated to cover requirements of the work.
      3) Establish mix designs through an approved design laboratory.
      4) Design concrete mix for protection against alkali-aggregate reactivity.
      5) The Contractor may present for approval a concrete mix previously approved for Authority work provided such mix is made with proposed ingredients that meet requirements and provided that concrete has complied with compressive-strength requirements based on control record of at least 30 consecutive-strength tests recently obtained.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Aggregates :
   1. Transport and stock pile aggregate separately according to sources and gradations. Handle so as to prevent segregation, loss of fines and contamination by earth or other foreign materials.
   2. If aggregates show segregation or if different grades become mixed, rescreen before placing in proportioning bins.

3. Do not combine aggregate from different sources or of different gradations except to obtain different gradations.
4. Do not transfer aggregates directly from trucks, railroads cars or barges to proportioning bins when moisture content is such that it will affect accurate proportioning of concrete mixture. In such cases, stockpile aggregate until excess moisture drains off.

B. Packaged Cement:
1. Deliver to project site in original sealed packages labeled with weight, name of manufacturer, brand and type.
2. Store packages in watertight building.
3. Do not use cement which has been reclaimed by cleaning bags.
4. Do not use cement which has been exposed to moisture or contaminated.
5. Deliver packages conforming to weight specified.
6. Packaged cement will be subject to testing.

C. Bulk Cement:
1. Store bulk cement separately from other cement and protect to prevent exposure to moisture and contamination.
2. In ready-mix plant, provide facilities to maintain separation of cement meeting specified requirements from other cement.
3. Provide in cement manufacturer's plant, facilities for sampling cement at weighing hopper or in feed line immediately before entering hopper.

D. Ready-Mixed Concrete: ASTM C94.

E. Blast-Furnace Slag or Fly Ash for use with Portland Cement:
1. Transport in covered carriers.
2. Store in watertight bins or silos to provide protection from dampness and contamination. When compartmented bins are used, conduct periodic, but not less than weekly checks between adjacent bins to avoid contamination of either of the stored materials.

F. Concrete Additives, Sealers and Corrosion Inhibitor . As required by the manufacturer.

1.05 WARRANTY

A. Penetrating Concrete Sealer: Provide a minimum effective service life warranty of 10 years for the penetrating concrete sealer.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Cementitious Materials:
1. Portland Cement: ASTM C150, Types I and II. Use Type II only for underground structures.
a. Alkali content not to exceed 0.6 percent.
2. Blended Hydraulic Cement: ASTM C595 Type IS and IP.

B. Ground-Iron Blast Furnace Slag: ASTM C989, Grade 100 or 120.

C. Fly Ash: ASTM C311 and ASTM C618, Class F:
1. Loss on ignition not to exceed 4 percent.

2. Maximum available alkalis (for combination of cement and fly ash) not to exceed 0.6 percent based on proportions to be used and alkalinity measurements for cement and fly ash individually or in combination.
   a. Fly ash used to be qualified for each source.
3. Uniform color when used in concrete exposed to public view.

D. Aggregates:
1. Aggregates for normal concrete and shotcrete: ASTM C33 with the following additional requirements:
   a. Coarse aggregate: Gravel, crushed gravel or crushed stone.
      1) Deleterious substances:
         a) Maximum allowable amounts:

Substance		Maximum Allowable Percentage by Weight
(1)	Soft particles:	5.0
(2)	Coal and lignite particles:	0.5
(3)	Friable particles:	0.25
(4)	Material passing Size 200 sieve:	1.0
(5)	Thin or elongated pieces:	15.0
(6)	Other local deleterious substances:	1.0

         b) Soft particles: Higher percentage may be approved where concrete is not subject to abrasion, provided concrete strength is achieved without the use of excess cement.
         c) Crushed aggregates: If material finer than Number 200 sieve consists of dust of fracture essentially free from clay or shale, percentage may be increased to 1.5.
         d) Thin or elongated pieces: Length of pieces to be greater than five times the smallest dimensions of a circumscribing rectangular prism.
      2) Percentage of wear: 45 maximum when tested in accordance with ASTM C131 and ASTM C535.
      3) Weighted percentage of loss: 15-percent maximum by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.
      4) Gradation: In accordance with ASTM C33, Table 2, and represented by a smooth gradation curve within required limits.
   b. Fine aggregate:
      1) Washed natural sand or washed stone sand. Stone sand may be subject to special gradation requirements as directed.
      2) Gradation in accordance with ASTM C33.
         a) Minimum percentages of material passing Size 50 and Size 100 sieves may be reduced to five and zero, respectively, if aggregate is to be used in concrete with three percent minimum air entrainment, or in concrete containing more than 517 pounds of cement per cubic yard.
      3) Weighted percentage of loss not more than 12 percent by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.
      4) Deleterious Substances:

Substance		Maximum Allowable Percentage by Weight
a)	Friable particles:	1.0
b)	Coal and lignite:	0.5
c)	Material passing the Size 200 sieve:	5.0
d)	Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles:	2.0

5) Free from injurious amounts of inorganic impurities as determined by ASTM C40. Should materials fail to pass test for organic impurities in sand for concrete, retest in accordance with ASTM C87. If fine aggregate shows by colorimetric test a darker color than that of sample originally approved for the work, stop using such aggregate until approved tests have been made to determine whether change in color is indicative of injurious amount of deleterious substances.

c. Evaluate for potential alkali aggregate reactivity:

1) Perform a petrographic examination in accordance with ASTM C295. The petrographic analysis will identify the constituents of the fine and coarse aggregate and will also identify aggregate found to be potentially alkali-carbonate reactive. Fine and coarse aggregate containing more than the following quantities of constituents is unacceptable:

a) Optically strained, microfractured or microcrystalline quartz exceeding five percent (a common constituent or granite and granite gneiss).

b) Chert, Metaquarzite, Chalcedony or combination thereof exceeding three percent. However, fine aggregate may contain up to eight percent provided that mortar bar test results are acceptable.

c) Tridymite or cristobalite exceeding one percent.

d) Opal exceeding five percent.

e) Natural volcanic glass in volcanic rocks exceeding three percent.

2) Test aggregate for alkali-silica reactivity in accordance with ASTM C1260. Aggregate sources that exhibit a C1260 mean mortar bar expansion at 16 days greater than 0.08 percent are unacceptable.

3) Aggregate identified by the petrographic analysis to be potentially alkali-carbonate reactive is to be further evaluated in accordance with ASTM C586. Expansion of test specimen cylinders not to exceed 0.10 percent after 28 day immersion in NaOH solution.

d. Aggregate which fails the evaluation criteria for potential alkali aggregate reactivity may be reclassified as acceptable if prior field performance demonstrates that the aggregate is nonreactive. Include service records (material records, batch quantities, exposure conditions, and petrographic evaluation) demonstrating the aggregate to be nonreactive in the mix design submittal.

2. Aggregates for Lightweight Structural Concrete: ASTM C330, with the following additional requirements:

a. Coarse aggregate:

1) Composition: Expanded shale, clay or slate, predominantly lightweight, cellular and granular.

2) Percentage loss: 10-percent maximum by weight when subjected to five cycles of the magnesium sulphate soundness test in accordance with ASTM C88.
3) Gradation: In accordance with ASTM C330, Table 1.
4) Unit weight: In accordance with ASTM C330, Table 2.

b. Fine aggregate:
1) Composition: Particles of expanded shale, clay, slate or ASTM C33 natural sand as necessary to obtain specified compressive strength and comply with specified air-dry unit weight for lightweight structural concrete.
2) Gradation: In accordance with ASTM C330, Table 1.
3) Unit weight: In accordance with ASTM C330, Table 2.
4) Percentage loss: 10 percent maximum by weight when subjected to five cycles of magnesium sulfate soundness test in accordance with ASTM C88.

E. Water:
1. Natural potable water with no pronounced taste or odor.
2. Containing no impurities, suspended particles, algae or dissolved natural salts in quantities that will cause:
a. Corrosion of reinforcing steel.
b. Volume change that will increase shrinkage cracking.
c. Efflorescence.
d. Excessive air entraining.
3. pH: Not less than five.
4. When tested in accordance with AASHTO T26, standard mortar-briquette tests to show no indication of unsoundness, no change in setting time in excess of plus-or-minus 30 minutes and no reduction in strength in excess of 10 percent.

F. Ready-Mixed Concrete: ASTM C94, Option C.

G. Admixtures:
1. In accordance with the following:
a. Air-entraining admixtures: ASTM C260.
b. Chemical admixtures: ASTM C494.
2. Approved brands: Chlorides may be present in admixtures provided total chloride in mixing water of proposed concrete mixture, including chloride ions contributed by admixture or admixtures, aggregate and mixing water is not in excess of 150 ppm.
3. Meeting requirements of reference standards or documented to have five-year minimum history of demonstrably satisfactory performance for similar structures under equivalent conditions.

H. Aluminum Powder: FS A-A-341A, free of oil, grease, soluble alkalis and organic materials, gradation as approved.

I. Ferrous Aggregate:
1. Cast-iron particles, ASTM A43, ASTM A47, or ASTM A48, free of oil, grease, soluble alkalis and organic materials.
2. Aggregate graded as follows:

Sieve Designation US Standard Square Mesh	Percentage by Weight Passing Individual Sieves
3/8 inch	—
Size 4	100
Size 8	90 - 100
Size 16	75 - 90

Size 30	45 - 60
Size 50	15 - 25
Size 100	10 - 20

3. If recommended by manufacturer and approved, in lieu of the above gradation use lower percentage of aggregate passing Size 100 sieve.

J. Abrasive Aggregate: 60 to 75 percent silicon-carbide abrasive, bonded by vitreous ceramic material, black, graded from 12 to 30.

K. Floor Treatment:
1. Sealer: Zinc or magnesium fluosilicate and wetting agent formulated and mixed with water in concentration recommended by manufacturer.
2. Floor hardener system:
   a. Floor hardener:
      1) Free from non-ferrous metallic particles, filler material, silica sand, natural aggregates, rust and materials which disguise rust.
      2) Ready-to-use formulation proportioned, mixed and packaged at factory ready for application.
      3) Ingredients proportioned to maintain two parts well-graded iron aggregate to one part consisting of cement, plasticizing agents and other ingredients designed to absorb moisture from floor slab.
      4) Color: Per sample, or as selected by the Engineer.
      5) Masterplate 200, Master Builders, or equal.
   b. Floor curing compound:
      1) Clear modified-acrylic resin.
      2) Moisture retention: In accordance with ASTM C309 when applied at a rate of 400 square feet per gallon.
      3) Masterkure, Master Builders, or equal.

L. Penetrating Concrete Sealer:
1. Penetrating silane sealer, which is readily absorbed into concrete substrate and which reacts chemically to provide a hydrophobic barrier that will not wear off when exposed to sunlight or wheel traffic; which allows concrete to breath, allowing the escape of water vapor but preventing the absorption of surface water; colorless; not altering the surface texture of the concrete substrate. See Warranty requirements.
2. Provide one of the following:
   a. Chem-Trete BSM 40, Hüls America, Inc. (1-800-828-0919).
   b. Penetrating 40, Sonneborn Division Chemrex (1-800-CHEMREX).
   c. Master Seal SL40, Master Builders Technologies.

M. Curing Materials:
1. Plastic sheeting: Polyethylene, ASTM C171.
   a. Curing sheet: Type 1.1.1 and 1.1.2.
   b. Vapor barrier: Clear 10-mils thickness.
2. Burlap sheet: AASHTO M182, Class 3 or 4.
3. Tarpaulin: FS K-P-146.
4. Blanket insulation: FS HH-I-521.
5. Membrane-forming curing compound: ASTM C309, Type 1-D, 100 resin with fugitive dye, and Type 2.

N. Epoxy Mortar:
1. Epoxy: ASTM C881, Type III-C, grey.
2. Sand: Clean, dry, well-graded particles, passing Size 16 sieve, with the following additional requirements:

Individual Sieve Size	Percent by Weight Retained on Sieve

30	26 to 36
50	18 to 28
100	11 to 21
Pan	25 to 35 (range shown is applicable when 60 to 100 percent of pan is retained on Size 200 sieve)

O. Chemical Grout: Section 02415.

P. Paver Tile Setting Bed:
1. Concrete: 3500 psi.
2. Reinforcement: 4 x 4 - W4.0 x W4.0, Section 03200, furnish in sheets, not rolls

Q. Elastomeric Concrete:
1. Elastomeric Concrete to consist of an aggregate and binder mixture proportioned by the manufacturer.
2. Manufacturer qualifications: Manufacturer to have the following minimum qualifications:
   a. Ten years experience in the manufacturing of elastomeric concrete materials.
   b. Qualified personnel, factory trained and certified in the proper installation procedures, are to be available during construction.
3. Manufacturers: The naming of certain manufacturers is intended to establish a standard of quality. Elastomeric Concrete from the following manufacturers is acceptable:
   a. Delcrete Elastomeric Concrete by the DS Brown Company, PO Box 158, North Baltimore, OH 45872, telephone (419)257-3561.
   b. Wabocrete by Watson Bowman Acme Corporation, 95 Pineview Drive, Amherst, NY 14228, telephone (716)691-7566.
4. Equal Products: Other manufacturers or material suppliers who wish to propose their product as equal to this specification submit product information and a working sample along with independent physical test property verification, and product literature for review and approval.

R. Waterstop: Section 03100.

S. Chairs for Reinforcement: Plastic or stainless steel.

T. Corrosion-inhibitor in concrete. The corrosion-inhibitor shall be calcium nitrite-based admixture DCI or approved equal. Use four (4) gallons per cubic yard of the corrosion inhibitor when the water-cement ratio is 0.40 or less and use three and a half gallons (3-1/2) per cubic yard when water-cement ratio is 0.38 or less. For precast prestressed parking structures/garages use the corrosion -inhibitor in cast-in-place concrete overlay topping over the double tees and the inverted tee beams on top level and for cast-in-place concrete in wash strips and wash areas on all levels.

2.02 SAMPLING:

A. Sample concrete ingredients prior to use and have them tested by an approved laboratory in accordance with methods specified. Subsequently test materials as often as necessary to verify that materials conform to specified requirements and that quality of product is maintained.

B. Make arrangements for the Engineer to witness sampling and testing. Submit record of test results.

C. Ready-Mixed Concrete: ASTM C94.

2.03 GROUT MIXES:

A. Portland-cement grout:
1. Prepare grout composed of portland cement, sand and water.
2. Use portland-cement grout under bearing plates, in recesses, holes and surfaces under structural members and at other locations shown.
3. Do not use staining ingredients in grout exposed to view.
4. Formulation: Two parts sand and one-part cement measured by volume.
5. Mix grout with sufficient water to permit placing and packing, approximately 45 minutes prior to use.

B. Nonshrink grout: ASTM C1107.

C. Shrinkage-compensating grout:
1. Use shrinkage-compensating grout for setting structural members, anchor bolts, embedded items or items of equipment and machinery on hardened concrete.
2. Prepare nonstaining shrinkage-compensating grout with portland cement, sand and aluminum powder and use in accordance with manufacturer's recommendations.
3. Prepare shrinkage-compensating grout for use up to two inches thick as follows, measured by volume:
   a. One-part portland cement, Type I or II.
   b. One-part fine natural-sand aggregate, graded as specified.
   c. One-part ferrous aggregate, graded as specified, combined with Type-A chemical admixture, oxidation agent and water in sufficient amount to permit placing and packing.

D. Premixed shrinkage-compensating grout:
1. In lieu of specified shrinkage-compensating grout, use premixed ready-to-use formulation when approved. Approval will be based on manufacturer's certification that:
   a. Material will perform as specified.
   b. Composition and proportioning of grout materials is essentially as specified for shrinkage-compensating.
   c. Formulation has been used successfully in like applications for at least five years.
2. Proportion ingredients in accordance with the manufacturer's recommendations.

E. Mixing water:
1. Proportion mixing water in accordance with grout manufacturer's recommendation or to produce flowable mixture without segregation or bleeding.

F. Curing:
1. After grout has attained initial set, keep damp for 24 hours minimum.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL:

A. Classes of Concrete:

1. Classes of concrete are designated by numerals corresponding to their specified 28-day compressive strength in pounds per square inch as determined by ASTM C94.
2. Concrete classes used in this project are specified. Unless otherwise indicated, use Class 3500.
3. Each class of concrete may comprise one or more mixes determined by maximum size of aggregate, cement factor and types of admixtures used.
   a. Portland cement may be used alone or mixed with either ground-iron blast-furnace slag or fly ash. Do not use fly ash in architectural concrete exposed to public view.
   b. Maximum allowable ground-iron blast-furnace slag: 50 percent of the total weight of the portland cement and ground-iron blast-furnace slag mixture.
   c. Maximum allowable fly ash: 20-percent of the total weight of the portland cement and fly-ash mixture.
4. Concrete with fly ash or ground-iron blast-furnace slag may be used at locations shown on the drawings.

B. Types of Concrete:
1. Types of concrete are designated as Concrete Other than Lightweight and Lightweight Structural Concrete.

C. Minimum Cement Factor:
1. Observe minimum cement factor for various classes of concrete other than lightweight, as follows:

Class of Concrete	Minimum Cement Factor Bags Per Cubic Yard Of Concrete
5,000	6.5
3,500 - 4,000	6.0
2,500 - 3,000	5.0

* one bag of cement = 94lbs. of cement

2. If a mix of portland cement and ground-iron blast-furnace slag or portland cement and fly ash is used, the mix is the basis of determining the bags per cubic yard of concrete.

D. Air Entrainment:
1. Determine air content of concrete in accordance with ASTM C94.

E. Testing of Concrete:
1. General:
   a. Provide the Engineer with molds and concrete, and cast specimens for testing. In addition, furnish necessary testing equipment and tools to perform sampling, slump tests and yield tests. Furnish boxes for shipping samples.
2. Perform strength tests by making not less than one set of standard cylindrical test specimens for each 100 cubic yards of concrete or any portion thereof for each structure.
   a. For each work shift, when concrete is delivered, make at least one set of specimens. A set of test specimens consists of at least three standard cylinders from a batch.
   b. Perform slump tests, unit weight and air content tests with no less frequency than that of strength-specimen sets.
3. Concrete strengths:

a. Determine strengths from standard test specimens according to ASTM C31 and ASTM C172 and cured and tested in accordance with ASTM C39 by the testing laboratory. Core drilling and testing in accordance with ASTM C42.Consider the effects of corrosion-inhibiting admixture and other admixtures on the strength of the concrete, in the concrete mix design. The corrosion-inhibiting admixture and other admixtures must be present in the concrete used for the test of the proposed mix strength.
b. Compute and evaluate in accordance with ASTM C94.

F. Variability of Constituents in Concrete:
1. Take representative samples of concrete mortar.
2. Maximum allowable unit-weight variation of air-free mortar taken from consecutive batches as discharged from mixer:
a. Average of two mortar weights: 0.8-percent maximum.
b. Average of six mortar weights: 0.5-percent maximum.
3. Maximum allowable weight variation of coarse aggregate per cubic foot of concrete taken from consecutive batches as discharged from mixer.
a. Average of two weights: Five-percent maximum.

G. Batching Plant:
1. Arrangement:
a. Provide separate bins or compartments for each size or classification of aggregate and for bulk portland cement, ground-iron blast-furnace slag or fly ash.
2. Compartments:
a. Provide compartments of ample size, so constructed that materials will be kept separated under working conditions. Equip batching plant so that flow of each material into its batcher is stopped automatically when designated weight has been reached.
b. Weigh aggregates in separate weight batches with individual scales or cumulatively in one batcher on one scale. Weigh bulk cement on separate scale in separate weight batcher. Weigh ground-iron blast-furnace slag or fly ash on the same scale in the same weight batcher containing the bulk cement. Weigh and record bulk cement first; then add to the bulk cement, weigh and record the ground-iron blast-furnace slag or fly ash. Weigh and record the cumulative bulk cement and ground-iron blast-furnace slag or the bulk cement and fly ash.
c. Water amount may be measured by weight or volume. If measured by weight, do not weigh cumulatively with other ingredients.
d. Interlock batching controls so that charging mechanism cannot be opened until scales have returned to zero. Satisfy these requirements by semi-automatic batching system as defined in the Concrete Plant Standards of the CPMB, with specified interlocking, or by automatic-batching system as defined in the Concrete Plant Standard.
e. Arrange plant so as to continuously facilitate inspection of operations. Provide facilities for obtaining representative samples of aggregate from each bin or compartment for test purposes.
f. Deliver materials from batching equipment within limits specified in ASTM C94.
g. Subject to approval, accomplish batching in accordance with ASTM C685, in lieu of weight batching, provided batching plant complies with requirements of CPMB Concrete Plant Standards.
3. Water batcher and admixture dispensers:
a. Provide equipment for batching water and air-entraining or other admixtures at batching plant except in cases where mixing is to be performed at jobsite in paving mixers or in truck mixers.

b. Provide water-measuring device capable of measuring mixing water within specified requirements for each batch. Provide mechanism for delivering water to mixers so that leakage does not occur when valves are closed.
c. Interlock filling and discharge valves for water batcher so that discharge valve cannot be opened before filling valve is fully closed.
d. Introduce admixtures in solution form.
e. Provide measuring devices for admixtures capable of ready adjustment to permit varying quantity of admixture to be batched. Interlock dispenser for admixtures with batching and discharging operations so that batching and discharging of mixture will be automatic.
f. If noninterlocked dispensers are permitted, check calibration of dispensers at directed intervals. Record results of such calibration for inspection by the Engineer.

4. Moisture control:
   a. Provide plant capable of ready adjustment to compensate for varying moisture contents of aggregate and to change weights of materials being batched. Provide approved electric moisture meter for measurement of moisture in fine aggregate. Calibrate as often as directed.
   b. Moisture content of fine aggregate not to exceed eight percent. Arrange sensing element so that measurement is made near batcher.
5. Scales:
   a. Provide accurate measurement facilities for and control of each of the materials entering each batch of concrete. Provide accurate weighing equipment in accordance with NBS Handbook 44.
   b. Include in each weighing unit a visual springless dial to indicate scale load at each stage of weighing operation or include beam scale with beam balance indicator to show scale in balance at zero load and at each beam setting, indicator to have undertravel and overtravel equal to at least five percent of capacity of beam.
   c. Provide standard test weights and other auxiliary equipment necessary to verify operating performance of each scale or other measuring device.
   d. Make periodic tests in the presence of the Engineer at directed intervals. Upon completion of each check test and before further use of indicating, recording and control devices, make adjustments, repairs or replacements as necessary to ensure satisfactory performance.
6. Recorders:
   a. Provide accurate recorder for producing digital printout of scale readings corresponding to each concrete ingredient of each concrete batch, including zero initial readings; indicate presence of each individual admixture by corresponding code in lieu of weight or volume record.
   b. Record water in gallons where batched by volume. In addition, on each printout show date and time of batching, identification number identical to that of concrete delivery ticket and codes for mix design and for project section.
   c. Prepare printout in duplicate and submit one copy with its corresponding concrete ticket at the time and site of concrete placement.
   d. House each recorder in locked cabinet.
   e. Place recorders in position convenient for observation by plant operator and the Engineer.
7. Protection:
   a. Protect weighing, indicating and control equipment against exposure to dust and weather; isolate against vibration or movement caused by other operating equipment.
8. Dry batching:
   a. When bulk cement and aggregates are hauled from central batching plant to mixers, place cement, ground-iron blast-furnace slag or fly ash for each

batch in an individual compartment which, during transit, will prevent cement from intermingling with aggregates and will prevent loss of cement.

b. Provide bins of batch trucks with suitable covers to protect materials.

c. Provide batch compartments of sufficient capacity to prevent loss in transit and to prevent spilling and intermingling of batches as compartments are being emptied.

H. Allowable Concrete Finish Tolerances:

1. Finish concrete elements to dimensions, elevations and positions shown within the tolerances specified for each:

a. Formed surfaces such as walls, roof soffits, columns, beams and girders: Plus-or-minus 1/4 inch.

b. Arches: Plus-or-minus 1/2 inch.

c. Bearing-assembly locations of aerial structure piers and abutments: Plus-or-minus 1/16 inch.

d. Traction-power substations, tie-breaker stations and ac-switchboard rooms: Plus zero or minus 1/4 inch.

e. Safety walks, vertical and horizontal: Plus-or-minus 1/2 inch.

f. Station platforms:

1) Vertical: Plus-or-minus 1/4 inch.

2) Horizontal, measured from centerline of track to edge of platform: Plus 1/4 inch or minus zero.

g. Invert slabs and floating slabs:

1) Maximum deviation from profile grade: Plus zero or minus 1/2 inch.

2) Maximum deviation from 10-foot steel straightedge: Plus-or-minus 1/8 inch, noncumulative.

3) Verify adequacy of finish for draining by hosing area. Ponding or obstructions to flow toward invert drains constitute defects.

h. Invert under floating slabs:

1) Maximum deviation from profile grade: Plus zero, minus 1/2 inch.

2) Maximum deviation from 10-foot steel straightedge: Plus-or-minus 1/8 inch, noncumulative.

I. Water tightness Criteria:

1. Maximum allowable water leakage:

a. Permanent-support lining for circular and horseshoe tunnels, including joints:

1) 0.14 gallons per minute per 250 linear feet.

2) 0.07 gallons per minute in any 10 linear feet.

b. Single-box, cut-and-cover line structures, including joints:

1) 0.12 gallons per minute per 250 linear feet.

2) 0.06 gallons per minute in any 10 linear feet.

c. Double-box or cross-over, cut-and-cover line structures, including joints:

1) 0.08 gallons per minute per 250 linear feet.

2) 0.04 gallons per minute in any 10 linear feet.

d. Passenger stations, other public spaces, NATM tunnels and two-pass system tunnels where full wrap-around waterproofing is used: No leakage permitted.

3.02 MATERIAL PREPARATION:

A. Mixing Concrete:

1. Operations:

a. Provide concrete mixers that discharge concrete of uniform composition and consistency.

b. Combine coarse aggregates of different gradation and identical sources, provided corresponding concrete mix has been approved. The use of alternate batches of gravel, crushed gravel or crushed stone of a single size is prohibited.

c. Adequacy of mixing will be determined by the Engineer by means of mixer performance tests in accordance with USBR Concrete Manual, Designation 26, Variability of Constituents in Concrete, in the appendix.

d. The Engineer may reduce size of batch to be mixed or increase mixing time when charging and mixing operations fail to produce concrete which conforms to specified requirements and which has uniform coloration and consistency.

e. Add water prior to, during and following mixer-charging operations. Do not overmix or add water to maintain consistency.

f. Use of concrete to which water in excess of amount permitted by approved design mix has been added to overcome conditions caused by excessive retention in mixer is prohibited.

2. Central-mixed concrete:

a. Arrange mixers in centralized mixing plant so that mixing action in mixers can be conveniently observed by the Engineer and plant operator.

b. Do not load mixers in excess of rated capacity. Mix concrete ingredients in batch mixer for not less than period of time specified for various mixer capacities after each ingredient except full amount of water is in mixer. Reduce mixing time if thorough mixing as specified can be obtained in less time and if approved.

c. Mixing time:

Cubic-Yard Capacity of Mixer	Mixing Time
2 or less	1-1/2 minutes
3	2 minutes
4	2-1/2 minutes
More than 4	To be determined per ASTM C94 tests by the Engineer

d. Equip each mixer with mechanically operated batch counter and timing and signaling device to indicate completion of mixing period.

3. Truck-mixed concrete: Use equipment and procedures that conform to the requirements of ASTM C94 and ACI 304, Chapter 5, with the following additional requirements:

a. Introduce materials, including water and mixtures, into the mixing drum only at the central batching plant, or

b. Transport aggregates from the central plant to the jobsite in the mixing drum and add measured and recorded cement, admixtures and water into the drum prior to mixing at discharge point.

c. When ice is used, add it with the water and counted as part of the water-cement ratio.

d. Place concrete within 90 minutes after cement is introduced into the mixing drum.

e. Accomplish initial mixing by 70 to 100 revolutions with drum rotating at the manufacturer's recommended speed. 30 revolutions at mixing speed will be required, if the addition of water is permitted. Do not exceed total of 300 mixing and agitating revolutions.

4. Temperature control:

a. Use preparation methods capable of producing concrete with temperature 85F maximum and 55F minimum at time of placement.

b. Do not heat concrete ingredients to temperature higher than that necessary to keep temperature of mixed concrete as placed within specified temperatures.

c. Do not heat water in excess of 140F.

B. Admixtures:

1. Introduce admixtures in solution form.

2. Air-entraining admixture: Use for concrete exposed to weathering or in contact with rock or moist soil.

3. Chemical admixtures:

a. Use water-reducing admixtures in concrete areas below grade in contact with rock, earth or fill.

b. Employ admixtures without interfering with specified air-content dosage of air-entrained concrete.

c. Except as otherwise specified or approved, use of water-reducing, set-retarding or set-accelerating admixtures is prohibited.

d. If introduction of certain admixtures to improve concrete strength is approved, do not reduce cement content below minimum amounts specified.

C. Consistency:

1. For concrete to be compacted by approved mechanical vibrators, maintain slump range at point of delivery within the following limits:

a. Concrete pavement, pavement base, sidewalk and incidental construction: Two to three inches.

b. Unreinforced concrete other than pavements: One to three inches.

c. Reinforced concrete: Two to four inches.

d. Concrete placed by pumping and concrete for filling steel-shell piles: Four to five inches.

e. Do not use concrete if slump exceeds maximum by 1/2 inch or more.

D. Lightweight Structural Concrete:

1. Prepare lightweight structural concrete with minimum cement content as follows:

Compressive Strength	Cement Content Bags Per Cubic Yard
2,000 psi	4 to 7
3,000 psi	5 to 8
4,000 psi	6 to 9
5,000 psi	7 to 10

2. Air-entrainment:

a. Use air-entraining admixture in lightweight structural concrete to provide not less than four nor more than six percent of entrained air.

3. Dry unit weight:
   a. Prepare lightweight structural concrete to provide air-dry weight required by design but not less than 90 pounds per cubic foot.
4. Consistency:
   a. Maintain slump range within two to four inches.

3.03 CONVEYING:

A. General:
1. Provide equipment for conveying concrete from mixer with continuous flow of concrete to point of placement without segregation.
2. Provide arrangement at discharge end of conveyor to prevent segregation.
3. Design long conveyor runs to discharge concrete into hopper, without segregation, before it is deposited in forms.
4. Ensure that pumps, pneumatic equipment, pipes, chutes and troughs are cleaned of dirt and concrete before use.

B. Chutes and Troughs:
1. Use only ferrous-metal-lined chutes and open troughs. Where steep slopes are unavoidable, equip chutes or troughs with baffles to minimize segregation of aggregates. Keep chutes or open troughs clean of hardened concrete by flushing with water after each use.
2. Discharge water used for cleaning outside lines of structure. Lay out chutes or open troughs with slope one-foot vertical to two feet horizontal maximum and one-foot vertical to three feet horizontal minimum.
3. Discharge chutes 20 feet or more in length into hopper before final distribution.

C. Adjustable Length Pipes (Elephant Trunks):
1. Use flexible pipes of ferrous metal, rubber or plastic, six inches minimum diameter so as to prevent segregation of concrete.
2. Position chutes or flexible pipes so that concrete is delivered in continuous flow to points not more than five feet horizontally and five feet vertically from final location. In vicinity of expansion and contraction joints, reduce horizontal distance to three feet maximum.
3. Clean flexible pipes and elephant trunks after each use.

D. Buggies:
1. Construct runways for buggies so they will not come into contact with or be supported by reinforcing steel of structure.

E. Pumping and Pneumatic Conveying Equipment:
1. Use pumping and pneumatic conveying equipment, designed to handle without segregation types, classes and volumes of concrete to be conveyed.
2. Operate pump or pneumatic equipment so that continuous stream of concrete without air pockets is produced. Position discharge end of line as near final position of concrete as possible but in no case more than five feet away.
3. At conclusion of placement, clean equipment. Discharge debris and flushing water outside of forms.

3.04 PLACEMENT:

A. General:
1. Prior to placing concrete, remove debris and extraneous material from interior of forms.

2. Place first lift of concrete on wet surface. Consolidate by dragging vibrator along edges of joints. Make sure there is no free or standing water over the surface.
3. Place concrete continuously and as rapidly as possible after mixing. Do not use vibrators for shifting mass of fresh concrete.
4. Place concrete in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams or planes of weakness. Cover each layer of concrete with fresh concrete within 45 minutes.
5. Do not place concrete which has attained initial set or concrete which has contained mix water for more than 90 minutes.
6. Remove temporary spreaders in forms when concrete has reached elevation which makes them unnecessary.
7. Place column concrete using adjustable-length flexible pipes or elephant trunks to avoid dropping concrete over five feet. In monolithic placements, do not deposit concrete in supported elements such as beams, girders and slabs until concrete previously deposited in columns or walls has completed its settlement shrinkage, but not to the point at which concrete in supporting members will not permit vibrator to sink into its mass of its own weight.
8. Placing will not be permitted when sun, heat, wind or limitations of facilities will prevent finishing and curing.
9. Concrete temperature at time of placement:
   a. 55F, minimum.
   b. 85F, maximum.
10. Unless approved, do not continue concreting when descending ambient air temperature falls lower than 40F.
11. Prior to placing fresh concrete against rock or previously placed concrete, take necessary steps, such as flushing with water, to ensure removal of foreign matter which would adversely affect bond.
12. Maintain wire fabric and other reinforcing in proper position on chairs during concrete placement.

B. Underwater Concrete Placement:
1. Place concrete carefully and continuously in compact mass by means of tremie or underwater bottom-dump bucket; do not disturb after depositing. Maintain still water at point of deposit. Use tight forms. In placing concrete, produce approximately horizontal surfaces.
2. Do not perform pumping within area until concrete has set at least 48 hours.
3. Tremie:
   a. Provide tremie consisting of watertight tube, 10-inch minimum diameter, with hopper at top. Equip tube with device to close discharge end and prevent water from entering tube while charging tube with concrete.
   b. Support tremie so as to permit free movement of discharge end over entire top surface of work and to permit rapid lowering when necessary to retard or stop flow of concrete.
   c. Close discharge end at start of work to prevent water entering tube and maintain entirely sealed, except when concrete is being placed. Keep tremie tube full of concrete.
   d. Maintain continuous flow until work is complete and resulting concrete seal is monolithic and homogenous. Control tremies so that concrete will be effectively compacted into horizontal layers not more than 12 inches thick.
   e. Space tremies so as to avoid segregation.

C. Consolidation:
1. Consolidate concrete thoroughly as it is placed in order to secure a dense mass. Work concrete well around reinforcement, embedded items and into the corners of forms. Consolidate concrete in accordance with ACI 309.
2. Use internal vibrators unless external vibrators are approved.

3. Use vibrators capable of generating frequencies of not less than 7,000 impulses per minute. Verify that vibrators have power and amplitude factor so as to visibly affect mass of concrete of one-inch slump over radius of at least 18 inches. Prevent formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove excessive water by pumping or other approved means.
4. When consolidating concrete in haunches, girders, beams or slabs, ensure that vibrator penetrates and revibrates previously placed concrete in top of supporting members.
5. Do not use vibrators where internal vibration might cause damage to embedded items; in such cases spading is required.

3.05 CURING AND PROTECTING:

A. General:
1. Protect freshly placed concrete from excessively hot or cold temperatures. Maintain without drying for period of time necessary for hydration of cement and proper hardening of concrete.
2. Provide sufficient tarpaulins to cover completely or enclose forms and working areas prior to and during placing and finishing operations.
3. Cure newly placed concrete continuously for seven days at ambient temperature in excess of 55F.
4. Cure concrete in subway structures by normal curing method specified.
5. During curing period keep steel and wood forms wet. If forms are removed during curing, use one of the following methods of curing immediately and continue for remainder of the curing period.

B. Normal Curing and Protection:
1. Use one of the following methods for flat surfaces, weather permitting:
   a. Use ponding on horizontal surfaces providing surface is continuously submerged for required curing period.
   b. Apply continuous sprinkling with nozzle or nozzles which, during first 24 hours, atomize flow of water providing a mist and not a spray. Do not apply moisture under pressure directly upon concrete; avoid flowing or washing on surfaces while susceptible to erosion.
   c. Cover entire surface of concrete with double thickness burlap sheet, laid directly on concrete and kept continuously wet. Maintain in good condition.
   d. Sprinkle concrete surface as specified for at least 18 hours and immediately cover with waterproof curing sheet, free from holes or tears. Hold in position so that entire surface of concrete is fully and continuously covered.
   e. Do not damage burlap, waterproof sheet or concrete surfaces.

C. Membrane-Forming Curing Compound:
1. Use curing compound when approved for circumstances where application of moisture is impracticable and where such compounds will not jeopardize appearance of concrete. Except as otherwise specified, use Type-1 compound, uniformly applied over surface at thickness recommended by manufacturer. Thoroughly mix compound and apply within one hour after mixing.
2. Where surfaces are subject to sunlight, apply Type-2 compound. Except for surfaces exposed to public view and architectural finished concrete.
3. Do not apply wax-resin curing compounds to surfaces requiring bond for additional concrete or where bonded surface coating such as paint, tile, dampproofing, waterproofing or roofing is to be applied.
   a. Do not apply curing compound to floors to be chemically sealed.

4. Warm or stir curing compound if necessary for satisfactory application in accordance with manufacturer's recommendations. If film of compound is damaged before expiration of curing period, repair immediately with additional compound.
5. Inside surfaces of tunnels, cut-and-cover boxes and other surfaces specifically approved may be cured with Type-1 membrane curing compound.
6. Finish surfaces prior to application of curing compound. Do not use curing compound on construction joints.
7. Apply curing compound in two coats. Apply first coat immediately after stripping of forms and acceptance of concrete finish.
8. If surface is dry, thoroughly wet concrete with water and apply curing compound just as surface film of water disappears. Apply second coat after first coat has set.
9. Protect coating against damage for at least 10 days after application. If damage occurs, apply additional coating.
10. If use of curing compound results in streaked or blotchy appearance, cease operations and use other method of curing until cause of defective appearance is corrected.

D. Floor Treatment:
1. In accordance with recommendations of manufacturer of floor hardener, apply floor curing compound and curing sheet to surfaces to receive floor hardener.
2. Where such surfaces are subject to sunlight, protect them by tenting white opaque, polyethylene waterproof sheet.

E. Protection of Rod Reinforcement:
1. After forms are removed, coat rod reinforcement and dowels extending beyond concrete surfaces with application of neat cement paste.
2. Remove hardened cement paste and resultant debris immediately prior to extension of reinforcement or installation of formwork.

3.06 COLD WEATHER CONCRETING:

A. Do not place concrete when ambient temperature is less than 55 º F and falling. Do not place concrete unless the form temperature at the time of placement is at least 40 º F.

B. When ambient temperature is 40 º F and falling, carry out one of the following procedures to protect placed concrete:
1. Heating:
   a. Enclose forms or structures and heat to maintain concrete and air within enclosure at not less than 55 º F for seven days after placement.
   b. Maintain relative humidity at not less than 40 percent during curing period when heat is applied to enclosures. Arrange stoves, salamanders or heaters so as to provide uniform distribution of heat. Vent combustion gases to outside air. Do not let hot air blow across concrete surfaces.
   c. After seven-day curing period, reduce temperature within enclosure gradually at maximum rate of 20 º F per day until outside temperature has been reached.
   d. Provide continuous and adequate fire protection and watchmen when heating units are in operation.
2. Form insulation:
   a. Insulate forms with blanket insulation of approved type and thickness to maintain concrete at 55 º F minimum for seven days.
   b. Protect top of placed concrete by tarpaulins or other approved waterproof material over insulation.

C. Do not allow concrete to freeze in a saturated condition prior to achieving a strength of 4000 psi.

3.07 HOT WEATHER CONCRETING:

A. When temperature in forms is 75F or above, carry out the following procedures to protect placed concrete:
   1. Protect concrete from direct sunlight.
   2. Keep forms moist by means of cool-water sprinkling or application of wet burlap or cotton mats.
   3. At 90F or above cool aggregates with water spray hoses.
   4. Cool truck barrels with water spray system.

3.08 JOINTS:

A. General:
   1. Unless otherwise shown make construction joints bonded joints by roughening surface to expose aggregates. Clean and roughen surface by wet sandblasting, by cutting with high-pressure water jet with a minimum pressure of 2,000 psi or by other approved means. Perform cleaning after concrete has hardened to prevent raveling of surface.
   2. Exercise caution in cleaning concrete to prevent damage to waterstops.
   3. Treat overlays on slabs the same as for rock or other bonded joint.
   4. Place construction joints at locations shown, or at locations approved by the Engineer.

B. Horizontal Construction Joints:
   1. Joints within 18 inches of tops of faces are prohibited.
   2. Trowel top surface of concrete adjacent to forms smooth to minimize visible joints on exposed faces. Remove laitance and other objectionable materials from joint surface to expose sound concrete as soon as concrete is firm enough to retain its form.
   3. Immediately after placement of concrete, remove accumulations splashed on exposed reinforcement and surfaces of adjacent forms before concrete attains initial set.

C. Other Joints:
   1. Place concrete for rock tunnels with vertical contraction joints, with vertical or sloping construction joints or continuously without joints.
   2. Install forms for vertical joints. Remove forms as soon as concrete has attained sufficient strength to be self-supporting.

D. Waterstops:
   1. Provide waterstops per Section 03100, Article 3.7.
   2. Rework or replace concrete where waterstop has moved unacceptably.
   3. Support water stop in exact position, do not sink water stops in fresh concrete.

3.09 CONCRETE FINISHING:

A. When forms are removed, do not remedy voids, stone pockets and other defects until the Engineer has inspected them and given directions.

B. Finish concrete surfaces as shown and as follows:
   1. Number-1 Form Finish:

a. Immediately following form removal, remove fins and irregular projections from surfaces exposed to view or those that will receive waterproofing.
b. Prepare pointing mortar not more than 30 minutes prior to use.
c. Cure mortar patches as specified under curing and protection.
d. Leave contraction joints and articulated joints in completed work carefully tooled and free of mortar and concrete.
e. Leave joint filler exposed for its full length with clean and true edges.
f. Apply this finish to structures, unless otherwise shown.

2. Number-2 Wet-Rubbed Finish:
   a. Start rubbing of concrete after removal of forms and as soon as its condition will permit. Keep concrete thoroughly saturated with water before starting this work.
   b. Allow sufficient time to elapse before wetting down to allow pointing mortar to thoroughly set. Rub surfaces with medium-coarse carborundum stone.
   c. Continue rubbing until form marks, projections and irregularities have been removed, voids are filled and uniform surface is obtained.
   d. Leave paste produced by rubbing in place. Obtain final finish by rubbing with fine carborundum stone and water after concrete above surface being treated has been cast. Continue rubbing until entire surface is of smooth texture and uniform color. After final rubbing is completed and surface has dried, rub with burlap to remove loose powder and objectionable marks.
3. Number-3 Broomed Finish:
   a. Where floors and other areas are shown to have rough finish, strike-off surface with screeds and wood floats at elevation shown.
   b. Before concrete has achieved initial set, broom transversely to flow of traffic with stiff, medium-bristle broom especially made for intended purpose to develop corrugations not more than 1/8-inch deep.
4. Number-4 Steel-Troweled Finish:
   a. Where floors are shown to have a steel-troweled finish, screed concrete to established grades and compact with wood or power-driven disc float.
   b. After surface has hardened sufficiently, finish with steel trowel to dense hard finish, free of trowel marks.
   c. Do not use dry cement or mixture of dry cement and sand to absorb water.
5. Number-5 Wood-Float Finish:
   a. Screed inverts of subway structure, floors not specified or shown to be finished otherwise, areas below floating slabs and areas to receive dampproofing, waterproofing or roofing to a true and uniform surface conforming to shape and elevations shown.
   b. Follow with wood-float finish to tolerances specified.
   c. On slabs and floors, where drainage is shown, maintain accurate slopes for drainage.
   d. Protect floors and slabs until final acceptance.
6. Number-6 Sandblast-Sealer Finish:
   a. Where concrete surfaces are shown to receive sandblast finish and a sealer prepare sample using sandblast finish on file in the Engineer's office as criterion.
   b. Prepare samples with degree of sandblasting which will produce uniform texture on surface of concrete. Blast to achieve smooth, sanded surface approximately equivalent to 100-120 grit sandpaper finish.
   c. Sandblasted surfaces will be inspected before sealing and compared with approved samples.
   d. Apply concrete surface sealer to sandblast finish in accordance with approved procedures.
7. Number-7 Natural-Board Finish:
   a. After stripping forms, cut back form ties as specified. Touch-up holes created by form ties and damaged or defective finish using grout closely

matching surrounding concrete. Accomplish grouting and repairs as specified. Knock-off heavy elongated fins, but do not rub down.

8. Number-8 Abrasive-Aggregate Finish:
   a. After screeding and floating as for Number-4 Finish, apply abrasive aggregate at rate of not less than 0.6 pound per square foot.
   b. Sprinkle evenly in two applications using one half the amount for each application. Apply second half at right angle to first.
   c. Follow with wood float; lightly tamp or roll surface to embed aggregate flush with concrete surface.
   d. Lightly steel trowel to smooth, even finish.
   e. After curing, rub surface using abrasive brick with water to slightly expose abrasive aggregate.

C. Do not sprinkle water or cement on surfaces to be trowel finished.

3.10 FLOOR TREATMENT:

A. Sealer:
1. Water cure floor surfaces to be sealed for 28 days minimum and ensure that they are completely dry before treatment.
2. Complete overhead work before sealer is applied.
3. Apply liquid floor sealer in three separate coats as recommended by the manufacturer using maximum quantity recommended. Allow to dry between applications.

B. Floor-Hardener System:
1. Areas of application: Concrete floor surfaces as shown.
2. Preparation:
   a. Strike concrete to established grade using wooden strike-off bar. Further level and consolidate concrete with wood bull float or wood darby immediately following strike-off. Complete before free moisture rises to surface.
   b. Begin floating adjacent to columns, forms and walls where concrete is most likely to stiffen first.
3. Application:
   a. Apply at uniform rate of 1.8 to 2.2 pounds of hardener per square foot of floor surface.
   b. Apply first shake to floated concrete adjacent to forms, columns, and walls where moisture will be lost first. Apply 2/3 of specified total shake immediately following floating of total area as follows:
      1) Distribute evenly.
      2) Throwing shake is prohibited.
      3) Perform hand floating with wood floats. Magnesium floats are prohibited.
   c. Use finishing machines with float blades as soon as shake has absorbed moisture as evidenced by darkening of surface. Do not allow float blades to dig into surface. Float sufficiently to bring moisture from base slab through shake.
   d. Immediately after floating first shake, apply remaining 1/3 of total specified shake in the same manner and machine float as specified. Plan operations to avoid necessity of sprinkling water on surface.
   e. As surface stiffens as evidenced by loss of sheen, finish by hand steel trowel removing marks and pinholes; leave surface in uniform condition with relatively smooth but nonslip surface.
4. Field service:

a. During installation, provide services of qualified representative of manufacturer to aid in proper use of product. Notify manufacturer three days minimum prior to initial application of product.

5. Quality control:

a. Prior to installation, submit for approval detailed quality-control plan describing method of application of floor hardener and listing items to be checked to ensure that materials are placed at proper time and in proper manner to achieve optimum durability of finished floor surface. Prior to submittal, have quality-control plan authenticated by qualified representative of material manufacturer indicating manufacturer's approval.

b. Submit quality-control reports authenticated by manufacturer's representative verifying that installation has been made in accordance with approved quality-control plan.

3.11 DEFECTIVE CONCRETE:

A. Concrete will be considered defective unless it is structurally sound, watertight, properly finished and within specified tolerances.

B. Concrete in place that is deemed structurally defective will be checked by the Engineer by drilled core specimens. If testing of core specimens shows that strength is less than 85 percent of specified strength, costs incurred in taking and testing of core specimens will be borne by the Contractor.

C. Replace, strengthen or correct defective concrete as directed.

3.12 PROTECTION FROM AND REMOVAL OF STAINS:

A. Protect concrete structure from rust staining by structural-steel members or from other substances during the work.

B. If staining should occur, remove stains and restore concrete to its original color.

3.13 DAMAGED WORK:

A. Before final acceptance of the work, neatly repair damaged surfaces, corners of concrete and concrete finish.

B. Where surface repairs are permitted, finish damaged areas to smooth, dense watertight condition.

C. Replace concrete that is not satisfactorily repaired.

3.14 CORRECTIVE WORK:

A. Submit corrective action patching procedure.

B. If correction of defects is approved, remove defective concrete; key area to be repaired, soak surface with water and patch with approved materials. Patch architectural concrete so as to match existing. Use bonding agents applied to the substrate or mixed with patching material only as approved by the Engineer.

C. Clean surface cavities produced by form ties, other holes, honeycomb spots, broken corners or edges and other defects. Saturate with water and point with mortar paste consisting of

cement and fine aggregate mixed in proportions to give same appearance as original concrete.

D. Prepare pointing mortar not more than 30 minutes prior to use. Cure mortar patches properly. Carefully tool contraction and articulated joints in completed work and keep them free of concrete. Where necessary, leave joint filler exposed for its full length with clean and true edges.

E. Tolerance deviations and other surface defects may also be corrected, if approved, by grinding high areas and swales. Leaks in station electrical rooms, TPSS and TBS shall be epoxy injected.

F. Where necessary or when directed, repair leakage in excess of specified maximum allowable, by means of contact grouting, chemical grouting or other approved means.

G. Where corrective work is unsatisfactory, completely remove such work and replace with new work complying with specified requirements.

3.15 EPOXY MORTAR REPAIRS:

A. Surface Preparation:
1. Remove defective concrete with chipping hammers or other approved equipment. To prevent removing extra material and causing cracks, saw-cut concrete area to be removed into maximum six-inch square checkerboard pattern 4-1/2 inches deep.
2. Prepare exposed concrete surface by sandblasting clean and allowing to dry thoroughly. Surface drying may be accomplished by air jet. Ensure that compressed air used in cleaning and drying is free from oil or other contaminating materials.
3. Maintain concrete surface in sufficient depth at temperature of 65F minimum during first four hours after placement of epoxy bond coat. Preheating may be done with radiant heaters or other approved means. Do not preheat concrete in excess of 200F with final surface temperature below 105F at time of placing epoxy materials.

B. Application of Epoxy Bonding Agents:
1. Prepare epoxy bonding agent in accordance with manufacturer's recommendations.
2. Apply epoxy bonding agent to prepared dry concrete surface at coverage of 80 square feet per gallon maximum or as recommended by manufacturer
3. Epoxy bonding agent may be applied by any convenient and safe method which will yield effective coverage, such as squeegees, brushes or rollers.
4. During application of epoxy bonding agent, ensure that material is confined to area being bonded; avoid contamination of adjacent surfaces. Extend epoxy bond coat slightly beyond edges of repair area.

C. Application of Epoxy Mortar:
1. Mix epoxy components in accordance with manufacturer's recommendations.
2. Proportion: 5-1/2 parts sand by weight to one-part epoxy.
3. Mix components with slow-speed mechanical device.
4. Prepare mortar in small batches so that each batch can be completely mixed and placed within approximately 30 minutes.
5. Do not add thinners or dilutants to mortar mixture.
6. Immediately after application of epoxy bonding agent, place, tamp, flatten and smooth epoxy mortar.
7. Work mortar to grade.
8. Steel-trowel finish. Trowels may be heated to facilitate finishing.

D. Curing:

1. Cure epoxy mortar repairs immediately after completion at 60F minimum until mortar is hard.
2. Initiate post-curing of four hours minimum at surface temperature of 90F minimum, 110F maximum.
3. Heat may be applied by using portable propane heaters, infrared heaters or other approved sources positioned to attain necessary surface temperature.
4. Do not subject epoxy-bonded epoxy mortar to moisture until after specified post-curing has been completed.

3.16 CONCRETE OVERLAYS AND TILE SETTING BEDS:

A. General:
1. Water blast (3,000 - 5,000 psi) or sand blast the substrate.
2. Keep slabs continuously wet for 24 hours prior to concrete placement. Substrate to be air blown just prior to concrete placement.
3. Place concrete in two pours of equal thickness. Place welded-wire-fabric reinforcement on first pour and then place second pour.
4. Use a vibratory screed on overlays.
5. Float slab and apply light broom finish. Cure slabs with water.
6. Remove laitance by methods in number one above if the overlay requires a bonding surface for tile or other treatments.
7. Continuously moist cure of overlay(setting bed) for seven(7) days.

END OF SECTION

SECTION 03331

CAST-IN-PLACE ARCHITECTURAL CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This Section specifies cast-in-place architectural concrete, including form work reinforcement accessories, concrete materials, concrete mix design, placement procedures, and finishes.

B. Related Work Specified Elsewhere:
1. Concrete Formwork: Section 03100 .
2. Concrete Reinforcement: Section 03200.
3. Cast-in-Place Structural Concrete: Section 03300.
4. Seals and Sealants: Section 07900.

1.02 DEFINITION:

A. Cast-in-Place Architectural Concrete: Concrete that is exposed to view on surfaces of the completed structure or building and that requires special concrete materials, formwork, placement, or finishes to obtain specified architectural appearance.

B. Design Reference Sample: Sample designated by The Engineer in the Contract Documents that reflects acceptable surface quality and appearance of cast-in-place architectural concrete.

C. Reveal: Projection of the coarse aggregate from the matrix after exposure.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:
1. Product Data: For each type of manufactured material and product indicated.
2. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
3. Shop Drawings: Show formwork construction including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie location and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural concrete.
4. Samples: For each of the following materials
   a. Form-facing panel.
   b. Form-release agent.
   c. Form ties.
   d. Form liners.
   e. Cement.
   f. Coarse- and fine-aggregate gradations.
   g. Chamfers and rustications.
   h. Curing compound.
   i. Coloring admixtures.
5. Samples for Verification: Architectural concrete samples, cast vertically, approximately 18 by 18 by 2 inches, of finishes, colors, and textures to match the design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.

6. Material Test Reports: From a qualified testing agency indicating and interpreting test results of the following for compliance with requirements indicated, based on comprehensive testing of current materials:
7. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
   a. Cementitious materials and aggregates.
   b. Admixtures.
   c. Curing compounds.
8. Placement Schedule: Submit concrete placement schedule before start of architectural concrete placement operations. Include location of all joints including construction joints.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. ASTM C 33, C 94, C 144, C 150, C 171, C 260, C 309, C 494, C 618, C 881, C920, C 979, C989, C 1077, C 1059, E 329, E 548, M 182
2. ACI CP-1,117, 301, 303, 303.1, 309R.
3. AAMA 810.1.
4. AASHTO M 182.

B. Installer Qualifications: An experienced cast-in-place architectural concrete contractor who has specialized in installing cast-in-place architectural concrete similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

C. Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

D. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program recognized by ASTM C 1077.

E. Source Limitations for Cast-in-Place Architectural Concrete: Obtain each color, size, type, and variety of concrete material and concrete mix from one manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.

F. ACI Standards: Comply with ACI 303.1, "Specification for Cast-in-Place Architectural Concrete"; ACI 301, "Specification for Structural Concrete"; and ACI 117, "Specifications for Tolerances for Concrete Construction and Materials," unless more stringent provisions are indicated.

G. Sample Panels: Before casting architectural concrete, produce sample panels to demonstrate the approved range of selections made under sample Submittals. Produce a minimum of 3 sets of full-scale sample panels, cast vertically, approximately 48 by 48 by 6 inches minimum, to demonstrate the expected range of finish, color, and texture variations.
1. Locate panels as indicated or, if not indicated, as directed by the Engineer.
2. Demonstrate methods of curing aggregate exposure, sealers, and coatings, as applicable.
3. In presence of The Engineer, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for

repair of tie holes and surface blemishes to match adjacent undamaged surface

4. Maintain sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
5. Demolish and remove sample panels when directed.

H. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings."

PART 2 - PRODUCTS

2.01 FORM-FACING MATERIALS:

A. General: Comply with Section 03300 for formwork and other form-facing material requirements.

B. Form-Facing Panels for As-Cast Finishes: Steel, glass-fiber-reinforced plastic, or other approved nonabsorptive panel materials that will provide continuous, true, and smooth architectural concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

C. Form-Facing Panels for As-Cast Finishes: Exterior-grade plywood panels, nonabsorptive, that will provide continuous, true, and smooth architectural concrete surfaces, high-density overlay, Class 1, or better.

D. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will provide surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

E. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

F. Form Liners: Units of face design, texture, arrangement, and configuration indicated or to match design reference sample. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.

G. Rustication Strips: Metal, rigid plastic, or dressed wood with sides beveled and back kerfed; nonstaining.

H. Chamfer Strips: Metal, rigid plastic, elastomeric rubber, or dressed wood, 3/4 by 3/4 inch, minimum; nonstaining.

I. Form Joint Tape: Compressible foam tape, pressure sensitive, AAMA 810.1, minimum 1/4 inch thick.

J. Form Joint Sealant: Elastomeric sealant complying with ASTM C 920, Type M or S, Grade NS, that adheres to form joint substrates.

K. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration from wood of set-retarding chemicals.

L. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

M. Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.

N. Form Ties: Factory-fabricated, glass-fiber-reinforced plastic, internally disconnecting or removable ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
1. Furnish ties with tapered tie cone spreaders that, when removed, will leave holes not larger than 3/4 inches in diameter on concrete surface.
2. Furnish internally disconnecting ties that will leave no corrodible metal closer than 1-1/2 inches, plus reveal projection of exposed aggregate, from the plane of architectural concrete surface.
3. Heavy-duty forms engineered to resist the concrete without ties, to avoid difficulty in matching concrete color and patching form tie holes, may be submitted for approval by the engineer. This procedure is applicable only for the architectural concrete arches indicated.
4. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.02 REINFORCEMENT ACCESSORIES:

A. Comply with Section 03200 and 3300 for steel reinforcement and other accessory requirements.

2.03 CONCRETE MATERIALS:

A. Portland Cement: ASTM C 150, Type I, II, or III, white color, use Type I unless otherwise approved in writing by the engineer, single source for entire Project.
1. Alkali content not to exceed 0.6 percent.
2. Fly Ash: ASTM C 618, Class C or F.
3. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Coarse Aggregate: ASTM C 33, single source for entire Project as follows:
1. Weathering Region and Class shall be 5S (severe).
2. Nominal Maximum Aggregate Size: 3/4 inch, uniformly graded.

C. Normal Weight Fine Aggregate: ASTM C144, natural sand from single source.

D. Water: Potable, complying with ASTM C94 except free of wash water from mixer cleanout operations.

E. Chemical Admixtures: Certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass, compatible with other admixtures and cementitious materials. Admixtures containing calcium chloride are prohibited.
1. Air-Entraining Admixture: ASTM C 260.
2. Water-Reducing Admixture: ASTM C 494, Type A.
3. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
5. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

F. Coloring Admixture: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures, free of carbon black; color stable, nonfading, and resistant to lime and other alkalis.
1. Color: As necessary or if necessary to match color of sample provided.

2.04 CURING MATERIALS:

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, washed to prevent concrete staining, weighing approximately 9 oz./sq. yd. when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Clear, Liquid Membrane-Forming Curing Compound: ASTM C 309, Type 1, ClassB.
   1. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
   2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

2.05 REPAIR MATERIALS:

A. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

B. Epoxy-Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:
   1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.06 CONCRETE MIXES:

A. Prepare design mixes for each type and strength of cast-in-place architectural concrete determined by either laboratory trial mix or field test data bases. Proportion concrete according to ACI 211.1 and ACI 301.

B. Use a qualified independent testing agency for preparing and reporting proposed concrete mix designs for the laboratory trial mix basis.

C. Proportion concrete mix as follows:
   1. Compressive Strength (28 Days): 4000 psi.
   2. Maximum Water-Cementitious Materials Ratio: 0.46.
   3. Maximum Slump: 4 inches.

D. Cementitious Materials: For cast-in-place architectural concrete exposed to deicers, limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements.

E. Air Content: Add air-entraining admixture at manufacturer's prescribed rate to result in architectural concrete at point of placement having an air content of 6 percent within a tolerance of plus 1 percent or minus 1.5 percent.Delete below if integrally colored concrete is not required.

F. Coloring Admixture: Add coloring admixture to architectural concrete mix according to manufacturer's written instructions.

2.07 CONCRETE MIXING:

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver cast-in-place architectural concrete according to ASTM C 94, and furnish batch ticket information.

B. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 90 to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 FORMWORK:

A. General: Comply with Section 03100 Concrete Formwork for formwork and embedded items.

B. Comply with ACI 303.1 limits on form-facing panel deflection.

C. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.
   1. Do not use rust-stained, steel, form-facing material.

D. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

E. Chamfer exterior corners and edges of cast-in-place architectural concrete.

F. Coat contact surfaces of wood rustications and chamfer strips with sealer before placing reinforcement.

G. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

H. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

I. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent mortar leaks

J. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

K. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.02 REINFORCEMENT AND INSERTS:

A. General: Comply with Section 03200 Concrete Reinforcement for fabricating and installing steel reinforcement.

B. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.03 REMOVING AND REUSING FORMS:

A. Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.

B. Leave formwork, for beam soffits, joists, slabs, and other structural elements, that supports weight of concrete in place until concrete has achieved at least 70 percent of 28-day design

compressive strength. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

C. Clean and repair surfaces of forms to be reused in the Work. Do not use split, frayed, delaminated, or otherwise damaged form-facing material. Apply new form-release agent.

D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for architectural concrete surfaces.

3.04 JOINTS:

A. Construction Joints: Install construction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Engineer.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
2. Use bulkhead forms with keys of plywood, wood, or expanded galvanized steel sheet, unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete. Align construction joint within rustications attached to form-facing material.
3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

B. Contraction Joints: Form weakened-plane contraction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by The Engineer.

3.05 CONCRETE PLACEMENT:

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement, unless approved by The Engineer.

C. Deposit concrete continuously between construction joints. Deposit concrete to avoid segregation.

D. Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.

1. Consolidate placed concrete with mechanical vibrating equipment. Use equipment and procedures for consolidating concrete recommended by ACI 309R.
2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator.

E. Cold-Weather Placement: Section 03300.

F. Hot-Weather Placement: Section 03300.

3.06 FINISHES, GENERAL:

A. Architectural Concrete Finish: Match The Engineer's design reference sample, identified and described as indicated.

B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.
   1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

C. Maintain uniformity of special finishes over construction joints, unless otherwise indicated.

3.07 AS-CAST FORMED FINISHES:

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding ACI 347R limits for class of surface specified.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Remove fins and other projections exceeding 1/8 inch in height.

C. Sand Blast-Sealer Finish: Section 03300.

3.08 CONCRETE CURING:

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures according to ACI 301.

B. Begin curing immediately after removing forms from concrete. Cure by one or a combination of the following methods that will not mottle, discolor, or stain concrete:
   1. Moisture Curing: Keep exposed surfaces of cast-in-place architectural concrete continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Continuous water-fog spray.
      c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
   2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period; use cover material and waterproof tape.
   3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.09 FIELD QUALITY CONTROL:

A. General: Comply with Section 03300 for field quality-control requirements

3.10 REPAIRS, PROTECTION, AND CLEANING:

A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by The Engineer. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.
   1. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to The Engineer's approval.

B. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.

C. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

D. Clean cast-in-place architectural concrete surfaces after finish treatment to removestains, markings, dust, and debris.

E. Wash and rinse surfaces according to concrete finish applicator's written recommendations. Protect other Work from staining or damage due to cleaning operations.
   1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

END OF SECTION

SECTION 04050

MORTAR, GROUT AND MASONRY ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing mortar, grout, and accessories for masonry work, including brick masonry, concrete unit masonry, granite and other stone masonry. The installation of such material is specified in the various masonry sections.

B. Related Work Specified Elsewhere:
1. Brick masonry: Section 04215.
2. Concrete unit masonry: Section 04220.
3. Granite: Section 04415.
4. Seals and sealants: Section 07900.
5. Flashing and sheetmetal: Section 07600.
6. Miscellaneous metals: Section 05500.
7. Concrete formwork: Section 03100.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Manufacturer's data: Recommendations for use of materials, preparation of substrate, limitations and special instructions for materials necessary to the work.
   b. Granite: Section 04415.
2. Samples:
   a. Three of each type of the following products used in the work:
      1) Mortars: Cured samples showing color of each type.
      2) Accessories: Representative samples of each type.
      3) Certification.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A36, A82, A153, A276, A666, A775, C114, C144, C150, C207, C270, C476, C665, C780, C881, C1019, D570, D638, D695, D1525, D2000, D2240, F593, F594.
3. FS: HH-I-521.

B. Source Quality Control:
1. Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from one manufacturer for each cementitious component and from one source or producer for each aggregate.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to job site in their original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.

B. Store products so as to prevent water intrusion, dampness and deterioration. Store loose materials sand and aggregates so as to prevent intrusion of foreign materials.

C. Handle products so as to prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not use materials or aggregates that are covered with frost. Do not mix mortar when the temperature is below that specified for masonry work.
2. Provide protective covering and heat as specified for masonry work.
3. Perform work under environmental conditions consistent with manufacturer's recommendations for materials being used in the work.

PART 2 - PRODUCTS

2.01 MORTAR AND GROUT MATERIALS:

A. Cement:
1. ASTM C150, Type I, portland cement, packaged in one-cubic-foot waterproof bags.
   a. For exterior walls, use low alkali cement; maximum 0.60 percent total alkali when tested according to ASTM C114.
   b. For below grade use type II cement and lime.
2. Cement for brick masonry:
   a. Factory-prepared, color-blended with nonstaining, inorganic coloring pigment.
   b. Pigments not to exceed 10 percent of weight of cement.
   c. Pigment blended in such quantity to produce cured mortar color matching face brick when mixed with hydrated lime and fine aggregate.

B. Hydrated Lime:
1. ASTM C207, Type S.
2. Uniform color for similar work.

C. Fine Aggregate: Clean, sharp, masonry sand, ASTM C144. For joints less than 1/4 inch, grade aggregate with 100 percent passing the Number 16 sieve.

D. Water: Potable.

E. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.

F. Admixtures: Do not add admixtures including air-entraining agents, accelerators, retarders, water repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

G. Epoxy for Epoxy Mortar: Two-component, ASTM C881, Type 3, Grade 3, Class C, with the following additional requirements:
1. Component A: Modified-epoxy resin of epichlorohydrin bisphenol A-type, containing suitable viscosity control agents and having epoxide equivalent of 180-200.
2. Component B: Primarily reaction product of aromatic amine and an aliphatic amine with epoxy resin of epichlorohydrin bisphenol A-type.
3. Ratio of Component A to Component B: By volume, 1:2.
4. Properties of mixed components:
   a. Solids content: 100 percent by weight.

b. Pot life: 20 to 30 minutes at 73F.
c. Tack-free time, thin film: Two to four hours at 73F.
d. Final cure, 75-percent ultimate strength, ASTM D695: Two days at 73F.
e. Initial viscosity, A plus B: 250 to 350 cps at 73F.

5. Properties of cured material:
   a. Tensile strength, ASTM D638: 5,000-psi minimum at 14 days, 73F cure.
   b. Tensile elongation, ASTM D638 modified: One to three percent at 14 days, 73F cure.
   c. Compressive strength, ASTM D695: 10,500-psi minimum at 28 days, 73F cure.
   d. Water absorption, ASTM D570: One-percent maximum.
   e. Bond strength: 2,000-psi minimum at 14 days.
   f. Hardened to hardened: 73F cure.
   g. Vicat softening temperature, ASTM D1525: 121F minimum.

H. Aggregate for Epoxy Mortar: Silica sand, Size 20 to Size 40, dust-free and moisture-free.

2.02 MORTAR AND GROUT MIXES:

A. Mortar Mixes for Brick Masonry: ASTM C270, types as follows:
1. Type S: For exterior loadbearing masonry and for masonry in contact with earth, proportioned by volume as follows:
   a. Portland cement: One part.
   b. Hydrated lime: 1/4 to 1/2 part.
   c. Fine aggregate: Not less than 2-1/2 nor more than three times sum of volumes of cement and lime.
   d. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.
2. Type N: For interior non loadbearing masonry, proportioned by volume as specified for Type S, except 1/2 to 1-1/4 parts hydrated lime.
3. Color: As shown or as selected by the Engineer.

B. Mortar Mixes for Concrete Unit Masonry: As specified for brick masonry, except pigment not required.

C. Mortar Mixes for Granite Setting Bed:
1. Granite, except paving, apron at pylons, platform edging, stair treads and landings: Nonstaining mortar composed of one-part portland cement and one-part plastic lime hydrate to four or five parts fine aggregate, ASTM C270, Type N. Pointing mortar of same composition, colored to matched granite.
2. Granite paving and granite apron at pylons: Nonstaining mortar composed of one-part portland cement to no more than four parts natural sand. For pointing use specified preshrunk mortar.
3. Stair treads and landings: Epoxy mortar consisting of one-part epoxy to 3-1/4 parts of aggregate by loose volume.
4. Platform edging: Epoxy mortar consisting of one-part epoxy to 1-1/2 parts of aggregate by loose volume.

D. Grout: For setting steel lintels and similar items, grouting mortar composed of one-part portland cement and two parts fine aggregate with sufficient lime putty added to obtain quick set.

E. Preshrunk Mortar: Dry, premixed, ready-to-use formulation.

2.03 ACCESSORIES:

A. Continuous joint reinforcement:

1. Accessories for Brick and Concrete Unit Masonry:
   a. Prefabricated continuous-reinforcing tie system fabricated of wire conforming to ASTM A82. Flush-welded cross ties, nine-gauge wire, hot-dip galvanized after fabrication in accordance with ASTM A153, Class B2, 1.50 ounces for side and cross rods.
   b. Fabricate joint reinforcement in straight lengths of not less than 10 feet of truss design with continuous diagonal cross ties spaced maximum 16 inches o.c.
      1) Make width of unit 1-1/2 inches to two inches less than thickness of wall.
      2) For multi-wythe wall, provide one side rod for each face shell of masonry more than four inches in width; plus one side rod for each wythe of masonry four inches or less in width.
      3) At cavity walls, provide integral drips on cross rods.Where horizontal joints of outer wythe does not align with back-up joints, provide adjustable two-piece tab design to engage the outer wythe by at least 1-1/2 inches.
   c. Corner reinforcement: Prefabricated, shop-welded corner-L and intersection-T units matching the continuous wall units.
   d. Spacing: See related work sections.
2. Dovetail anchors:
   a. Flexible, adjustable or corrugated 1-inch wide dovetail anchors of 12 gauge galvanized steel. Place anchors every 16 inches in height of wall at intersections of masonry walls and concrete, and for masonry furring of concrete. Dovetail slots are specified in Section 03100, by same manufacturer of anchors.
3. Wall plugs:
   a. Galvanized 26-gauge corrugated metal, approximately three inches long and of standard manufacture, where necessary for attaching other work.
4. Z-type rigid-steel anchors: Steel, ASTM A36, 1/4-inch thick by 1-1/2 inches wide by 28 inches long, galvanized; with one two-inch opposing 90-degree bend at each end.
5. Corrugated-steel anchors: 14 gauge by 1-1/4 inches by 20 inches with one two-inch 90-degree bend, with 18 inches of corrugation.
6. Steel framing anchors: Fabricated of 3/16-inch galvanized wire tie and galvanized flat-steel strap one-inch wide by 22 gauge or 3/4-inch wide by 12 gauge.
7. Weep-hole tubes: 3/8-inch OD, medium density, nonstaining, polyethylene tubes of lengths ensuring complete panel penetration and unobstructed flow.Fire-resistant compressible filler: Inorganic, non-asbestos mineral fiber safing insulation, with foil facing to impede smoke passage; moisture resistant, mildew-proof and vermin-proof, noncorrosive and nondeteriorating; UL-listed; meeting ASTM C665 and FS HH-I-521 Type III, except for identification marking.
8. Control joint gasket: Solid styrene-butadiene-rubber compound per ASTM D2000, 2AA-805, factory extruded into shapes for use with standard sashblock to provide stability to masonry walls at expansion and control joints; minimum shear strength 540 psi, durometer hardness 80 (plus or minus 5) per ASTM D2240. Provide T-shape and X-shape for vertical joints as appropriate, flat shape beneath load-relieving angles.
9. Cavity Drainage System: 1 inch thick by 10 inches high by 5 feet long section of high density polyethylene or nylon mesh designed to allow moisture to flow downward in cavity joint.
10. Masonry Cell Insulation: Molded polystyrene Insulation Units - Rigid, cellular thermal insulation formed by the expansion of polystyrene - resin beads or granules in a closed mold to comply with ASTM 578, Type I. Provide specially shaped units designed for installing in cores of masonry units.

B. Accessories for Granite:

1. Stainless steel, ASTM A276 or A666, Type 304, for anchors, cramps, angles, dowels, plates, bolts or other accessories in contact with stone.
2. Anchor sizes:
   a. Anchors with dowels: 3/16 inch by one inch in cross section.
   b. Two-way anchors: 1/8 inch by two inches in cross section.
   c. One-way anchors: 1/8 inch by one inch in cross section.
   d. Anchors to stone: Anchors of necessary length and of type that turn into stone minimum of 1/2 inch.
   e. Anchors to concrete: Heavy-duty sleeve style or wedge-type anchors with 3,000-pound hold-fast strength or anchors suitable for use with dovetail slots.
   f. Lewis anchors for lifting stones: 3/4 inch in diameter.
   g. Other anchors: Sizes as shown on approved shop drawings.
   h. Fasteners for Stainless-Steel Anchors: Annealed stainless-steel bolts, nuts, and washers; ASTM F593 for bolts and ASTM F594 for nuts.
   i. Setting Shims: Strips of vulcanized neoprene, 50 to 70 Shore A durometer, nonstaining to stone, sized to suit joint thicknesses and depths of stone supports without intruding into required depths of joint sealants or causing third-side adhesion between sealant and setting shims.
   j. Weep and Vent Tubes: Medium-density polyethylene tubing, 1/4-inch OD and of length required to extend from exterior face of stone to cavity behind.
3. Sizes for other accessories:
   a. Dowels: Minimum of 1/2 inch in diameter, designed to extend two inches into stone and two inches into concrete.
   b. Cramps: 1/8-inch by one-inch plate with 3/8-inch dowels at each end designed to extend into stone and concrete a minimum of one inch.
   c. Angles, plates, and bolts: Sizes as shown on approved shop drawings.

C. Steel lintels: Section 05500.

D. Masonry lintels: Section 04220.

E. Flashing: Section 07600.

PART 3 - EXECUTION

3.01 MIXING OF MORTAR:

A. Mix mortar materials in an approved clean mechanical mixer for at least three minutes and not more than five minutes with a minimum amount of water to produce workable consistency.

B. Mortar which has stiffened because of evaporation of water may be retempered by adding water as needed to restore necessary consistency. Use mortar within 2-1/2 hours of initial mixing.

C. Use an approved method of measuring materials and mortar that will control and accurately maintain specified proportions throughout the work. Shovel measure is prohibited. Measure sand in damp, loose condition.

D. Apply pre-shrunk mortar in accordance with the manufacturer's instructions.

E. For alteration and restoration work, tint or modify mix to match mortar of existing masonry.

F. The Engineer may direct a test of the mortar in accordance with ASTM C780 and a test of the grout for compressive strength per ASTM C1019 to establish compliance with specified requirements.

END OF SECTION

SECTION 04415

GRANITE

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing granite for architectural work.

B. Related Work Specified Elsewhere:
1. Mortar, grout and masonry accessories: Section 04050.
2. Seals and sealants: Section 07900.
3. Cast-in-place structural concrete: Section 03300.
4. Platform edge light glass lenses and sealant: Section 08800.

1.02 PERFORMANCE REQUIREMENTS:

A. Stone Abrasion Resistance: Minimum abrasive-hardness value of 12, as determined per ASTM C241.

B. Static Coefficient of Friction: ASTM C1028, values as follows:
1. Level Surfaces: A minimum of 0.6.
2. Step Treads: A minimum of 0.6.
3. Ramp Surfaces: A minimum of 0.8.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
a. Show the following:
1) Bedding, bonding and jointing of granite, including typical and special anchoring, expansion-joint details and interface with other work.
2) Dimensions and setting numbers of each stone in plan and elevation, including grading data for drainage.
2. Working Drawings:
a. Include full explanation of erection methods and installation procedures, temporary loading, anchor design, surface preparation, setting materials, bonding, testing and other work as directed.
b. For granite walls, include structural analysis data signed and sealed by the qualified professional structural engineer responsible for their preparation.
3. Samples:

a. Submit three sets of samples of each type of granite used in the work, showing full range of color, texture, veining, fissures and finish of each type; each sample 12 inches square by one-inch thick. Include a minimum of two pieces in each set with maximum number of pieces in each set as necessary to demonstrate full range and variations.
   1) Material delivered or erected not within approved range samples will be rejected.
b. Epoxy for mortar dams and epoxy fill and for setting dowels: Manufacturer's standard container.
c. Non-staining wedge.
d. Stainless steel dowel.
e. Platform edge glass lens and sealant: Section 08800.
   1) Cured six-inch long strip of grout matching existing white granite grout joint color for granite slab transverse joint grouting: Section 04050.
   2) Platform joint sealant: Section 07900.

4. Documentation:
   a. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
   b. Quality-Assurance Program.
5. Certification.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications.
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. NBGQA: Specifications for Architectural Granite.
   3. ASTM: C241, C615, C1028.

B. Qualifications of Granite Quarries:
   1. Obtain granite from approved quarries having capacity and facilities for furnishing the quantity, size and quality of granite required.
   2. Provide the product of one quarry matching approved samples.
   3. Source Limitations for Stone: Obtain each variety of stone, regardless of finish, from a single quarry with resources to provide materials of consistent quality in appearance and physical properties.
   4. Installer Qualifications: An experienced installer who has completed dimension stone cladding systems similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

C. Quality Assurance Program: Before installing granite edging, walls and stairs, construct mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed work.

1. Granite edging:
   a. Demonstration installation:
      1) Demonstration installation to consist of three adjacent units to be installed in the work or as otherwise directed.
      2) Perform work as shown and in accordance with approved shop drawings and working drawings, using specified materials.
   b. Testing:
      1) In the presence of the Engineer and in accordance with approved working drawings, test each unit of the demonstration installation by placing end of crowbar at each end of unit and prying with a force that would lift an unbonded piece of stone with 50 psf live load. Protect stone from touching crowbar directly. In the presence of the Engineer, before joint sealants are installed, test the bonded strength of each unit after two-hour cure time by applying an uplift load of 2,000 pounds at each drainage opening below the granite as approved.
      2) If a unit fails to pass test by lifting or cracking of unit or setting bed, remove unit, revise setting procedures and reset unit. Repeat, as necessary, until approval is obtained.
      3) Do not proceed with remainder of the work until demonstration installation, procedures and personnel are approved.
2. Stair treads and landings:
   a. Prior to erection at site, test each stair tread and stair landing to withstand live load of 300 psf for duration of not less than 15 minutes. Test only components which perform a structural function and are not supported over their entire length by cast-in-place concrete.
3. Granite walls:
   a. Build mockups of typical exterior wall with dimension stone cladding, approximately 72 inches long by 48 inches high or as directed by the Engineer.
   b. Show typical components, attachments to building structure, and methods of installation. Include sealant-filled joint complying with requirements in Section 07900.

D. Professional Structural Engineer Qualifications: A professional structural engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated.

Engineering services are defined as those performed for installations of granite wall cladding systems that are similar to those indicated for this Project in material, design, and extent.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Pack granite so as to prevent damage in transit, and deliver in accordance with Contract schedule and setting sequence.

B. Deliver each piece of granite with code mark on unexposed face, corresponding to shop drawings using nonstaining paint. Deliver and unload granite. Prevent damage and soiling during delivery and unloading of granite.

C. Protect from disfiguring elements.

D. Separate granite from wood skids with polyethylene or other nonstaining material. Store under waterproof covering, and keep dry.

E. Remove rejected stones from jobsite immediately.

1.06 JOB CONDITIONS:

A. Environmental Requirements:
   1. Do not use frozen materials or materials mixed or coated with ice or frost. Remove and replace dimension stone cladding damaged by frost or freezing conditions.
   2. Erection and pointing of granite when ambient temperature is below 50F and or tending to fall below 50F is prohibited.

B. Cold-Weather Protection: When night-time temperature is forecasted within 50 to 25 Deg F: Cover dimension stone cladding with a weather-resistant membrane for 48 hours after construction. Do not install granite when night time temperature is forecasted below 25 Deg.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Granite:
   1. Granite Building Stone Standard: ASTM C615.
   2. NBGQA Specifications for Architectural Granite, free from starts, cracks or seams which might impair its structural integrity or appearance.
   3. Color classification: Granite matching grain, color and variegation of all white, fine-to-medium-grain granite as listed in referenced NBGQA standard.
   4. Exposed surfaces finished in accordance with the following and as shown:

a. Type 1: Thermal finish or four-cut, slip-resistant.
b. Type 2: Six-cut, stippled.
c. Type 3: Honed-dull sheen without reflections.
d. Type 4: Split face, nominal depth of 3-1/2 inches. Use Type 4 for all Granite Sets.

5. Where stone thickness permits, provide lewis holes for lifting stones weighing over 100 pounds. Make lewis holes not closer than two inches from finished face of stone nor in exposed portions of stone.
6. For alteration and restoration work, use granite salvaged from existing work. If salvaged granite is not sufficient, provide new granite to match existing granite in type, size and appearance.

B. Mortar Materials and Granite Accessories: Section 04050.

C. Portland Cement Paste: Section 03300.

D. Granite platform edge glass lenses and setting materials:
1. Glass lenses: Salvage and reuse existing lenses to greatest extent possible. If Engineer determines existing lenses cannot be reused: Section 08800.
2. Glass lens sealant: Section 08800.
3. Lead shims or lead rope: Section 08800.

E. Dowels: Salvage and reuse existing dowels to greatest extent possible. If Engineer determines existing dowels cannot be reused: Dowels for platform edge granite slab dowels: Section 04050, minimum 1/2-inch diameter, of sufficient length to extend into stone 1/2 thickness of stone and to extend two inches into structural concrete.

F. Epoxy mortar and epoxy fill for mortar dams and epoxy for setting dowels for Granite Edge Slabs: Section 04050.

G. Non-staining shim wedges to support granite slabs during curing of epoxy mortar dams: As approved.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine surfaces to receive dimension stone cladding and conditions under which dimension stone cladding will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of dimension stone cladding.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

A. Runways, Scaffolds and Hoists: Provide and move scaffolding, temporary runways, temporary floors, staging and hoists in accordance with specified safety requirements.

B. Substrate: Remove foreign substances that would affect bond of mortar from surfaces to receive granite.

C. Advise installers of other work about specific requirements for placement of inserts, flashing reglets, and similar items to be used by dimension stone cladding Installer for anchoring, supporting, and flashing of dimension stone cladding system. Furnish installers of other work with Drawings or templates showing locations of these items.

3.03 FABRICATION AND ERECTION:

A. General:
   1. Fabricate granite in sizes and with joint patterns shown on Contract Drawings and approved shop drawings.
   2. Installation of granite which is not within the approved range of color, texture, finish, veining and fissures; is mismatched; shows flaws or imperfection in cutting; or has other defects is prohibited.
   3. Provide openings for installation of work of other trades in accordance with approved shop drawings. Coordinate size of rabbet at expansion joint in granite platform edging with the expansion joint dimension and the size of compression seal.
   4. Provide 1/4-inch joints, unless otherwise shown on Contract Drawings and approved shop drawings.
   5. Unless otherwise shown, completely fill joints in granite work and rake out to depth of 3/4 inch, except paving joints and pylon-apron joints showing grout.
   6. Set stones accurately in alignment with other stones and adjacent work. Set stones in full mortar beds. Level and plumb stones as work progresses.
   7. Set finish surfaces in true and even planes, with uniform jointing. Take up and reset loose, hollow sounding slabs. Leave surface free of mortar stain and other defacements.
   8. Where epoxy materials are used, follow manufacturer's recommendations.
   9. Granite paving over waterproofing: Carefully place granite and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.

a. Provide cork joint filler in accordance with Section 07900, where indicated, at waterproofing that is turned up on vertical surfaces or, if not indicated, provide temporary filler or protection until granite paving installation is complete.

B. Tolerances: Meet NBGQA Specifications for Architectural Granite.

C. Paving and Granite Apron at Pylons:
1. Do not put down more setting bed than can be covered in the same day.
2. Dust setting bed with portland cement and butter underside of stone with neat portland cement paste in accordance with Section 03300 and pound into place at proper elevation.
3. Where concrete is to be cast against stone, parge contact surface with not less than 1/2 inch of nonstaining setting mortar in accordance with Section 04050.

D. Benches: Provide bench seats and backs in one piece with no joints.

E. Walls:
1. Fabrication: Fabricate granite wall units in sizes and shapes required to comply with requirements indicated, including details on Drawings and Shop Drawings.
   a. Cut and drill sinkages and holes in granite for anchors, fasteners, supports, and lifting devices as indicated or needed to set stone securely in place; shape beds to fit supports.
   b. Cut granite to produce pieces of thickness, size, and shape indicated and to comply with fabrication and construction tolerances recommended by applicable stone association or, if none, by stone source, for faces, edges, beds, and backs.
   c. Minimum Thickness: 1-½ inches.
   d. Cut granite panels to produce joints of uniform width and in locations indicated.
   e. Provide minimum anchorage as follows and in accordance with standard practice:
      1) Not less than one anchor for every six square feet of stone.
      2) Minimum of two anchors at each head and bed joint.

F. Application to Floor Hatches and Other Metal Items:
1. Apply granite to recessed floor hatches and other metal surfaces by the use of epoxy mortar in accordance with Section 04050.
2. Use epoxy of type and brand recommended by manufacturer to set granite on metal and in accordance with Section 04050. Continue paving pattern of adjacent surfaces over hatch covers.

G. Application of Granite Platform Edging:

1. Set granite with epoxy mortar in accordance with recommendations of epoxy manufacturer, and with Section 04050 and with approved quality-assurance program.
2. Set dowels with epoxy mortar not less than 1-1/2 inches into granite. Allow mortar to cure to not less than 75 percent of its ultimate compressive strength.
3. Place epoxy mortar as shown, using mortar dams or other approved method of forming. Adjust as required to obtain full contact of epoxy mortar with granite. Apply epoxy mortar in a self-leveling consistency. Set granite, embedding it into epoxy mortar. To permit drainage, maintain spaces between mortar dams as shown.
4. Expansion joints: Coordinate the distance between granite edge stones with the required expansion joint size (width) for the temperature of the structure at the time stones are set. See structural drawings.
5. Install lamps in accordance with Division 16 and install lead shims, glass lenses, and seal lenses in accordance with Section 08800.
6. Resetting platform edge granite slabs:
    a. The following is Red Tag work and is limited to only the number of granite slabs that can be reset in one work shift:
        1) Preparation for raising granite slabs: Remove IRIIS screw anchors and metal wireway sections. Sawcut granite edge slabs' transverse joints both vertically and horizontally. Remove platform edge light lenses and lamps. Dig out epoxy bedding material.
        2) Provide and move staging and hoists in accordance with safety requirements and as approved. Lift up existing granite slab edge unit(s). Store units to be reset so as to prevent damage and discoloration. Replacement of damaged and broken slabs in kind is the responsibility of the Contractor.
        3) Remove dowels and salvage as many as possible of the existing stainless steel granite anchoring pins for re-use. Replacement of damaged and missing items in kind is the responsibility of the Contractor.
        4) Demolish existing epoxy setting dams that support granite and remove to expose structural slab.
        5) Clean and prepare surfaces of unit(s) and structural slab to receive new epoxy setting dams. Where existing concrete has not been treated with MMA, scarify slab to provide proper substrate for new epoxy mortar dams. Do not scarify MMA patches or MMA-treated concrete. Remove foreign substances that would affect bond of epoxy mortar from surfaces of concrete slab receiving granite.
        6) Laser survey or set string line as necessary to establish elevations for granite slabs as necessary.

7) Mix epoxy mortar in accordance with manufacturer's instructions and place mortar bulkheads or other approved forming method to form setting dams at a width to match existing and at a height as required to set granite slabs to proper elevation, leaving eight-inch wide drainage channels between setting dams. Pour neat epoxy between epoxy mortar bulkheads to a slighter higher elevation. Remove excess mortar and neat epoxy and adjust as required to obtain full contact between epoxy and granite.

8) Reset dowels or set new dowels as necessary at not less than two inches into concrete structural slab and to extend into granite 1/2 depth of granite. Set non-staining wedges for support to allow proper curing of epoxy dams when granite is reset.

9) Set original granite slab unit(s) on intermittent epoxy dams and dowels at proper elevations, providing uniform 1/4-inch joints between adjacent units, except as necessary to match existing. Set granite slabs accurately to corrective alignment between adjacent slabs and existing work and with finish surfaces in true and even planes. After each granite edge unit is set, take measurements to verify that unit is at proper elevation and location. Level and plumb granite slabs as work progresses. Take up and reset loose, hollow sounding units.

10) Install lead shims, reinstall platform edge lamps, and reinstall glass lenses and reseal lenses in accordance with Section 08800.

11) Remount IRIIS metal wireway sections with screw anchors.

12) After epoxy dams have cured, perform bond strength testing as previously specified.

H. Granite Sets:

1. Random ashlar pattern with broken course and range or stacked bond, as shown.

3.04 POINTING AND CLEANING:

A. Pointing:

1. After setting mortar has cured, point voids in joints of exposed granite paving and pylon aprons with preshrunk mortar. Remove excess mortar.
2. Seal joints in granite work with sealants in accordance with Section 07900, except paving joints and pylon-apron joints.

B. Cleaning:

1. Clean joint surfaces and remove dirt, coatings, moisture and other foreign substances which could interfere with bond. Recaulk granite edge slabs' transverse joints both vertically and horizontally with grout and let cure.
2. Thoroughly and carefully clean work by approved means and leave in first class condition, free from mortar or other defacement. Clean all exposed granite surfaces, including joints, with water and washing compound soap powder solution in accordance with recommendations of manufacturer. Sponge and wash thoroughly. Use of acid or acid cleaners is prohibited. Remove stains by approved means. Clean granite masonry surfaces, including those grouted or sealed, with soap-powder solution and fiber brushes to remove stains. Thoroughly and carefully clean work and leave in first-class condition, free from mortar stains or other defacement. Immediately after cleaning, rinse surfaces with clear water. Polish with clean dry cloths.

C. Protection:
1. Protect granite work from damage after erection. Provide protective boxing or other suitable means whenever necessary in the absence of specific instructions from the Engineer. Do not use materials that will stain or deface granite. Use galvanized nails in protective boxing.
2. Continuously protect granite work from water during construction and until installation is complete and is approved.
3. Protect granite work from traffic of any kind for not less than two hours after setting. Remove protection immediately after two hours curing.

3.05 FIELD QUALITY ASSURANCE:

A. Granite Platform Edging:
1. Perform work in accordance with approved quality-assurance program.
2. Change of procedures and personnel without approval is prohibited.

END OF SECTION

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SECTION 04450

EXTERIOR STONE CLADDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Dimension stone panels set with individual anchors.
2. Dimension stone panels set in architectural precast concrete.
3. Dimension stone trim units, including bands, copings, sills, and jambs.

B. Related Requirements:

1. Section 03300 "Cast-in-Place Concrete" for installing inserts and weld plates in concrete for anchoring dimension stone cladding.
2. Section 03450 "Precast Architectural Concrete" for setting dimension stone panels in architectural precast concrete units.
3. Section 04415 “Granite.”
4. Section 07900 "Joint Sealants" for sealing joints in dimension stone cladding system with elastomeric sealants.

1.03 DEFINITIONS

A. Definitions contained in ASTM C119 apply to this Section.

B. Dimension Stone Cladding Assembly: An exterior wall covering system consisting of dimension stone panels and trim together with anchors, mortar, adhesives, fasteners, and sealants used to secure the stone to the building structure and to produce a weather-resistant covering.

C. IBC: International Building Code.

1.04 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.05 SUBMITTALS

A. Product Data: For each variety of stone, stone accessory, and manufactured product.

B. Sustainable Design Submittals:

1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material

manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

C. Shop Drawings: Show fabrication and installation details for dimension stone cladding assembly, including dimensions and profiles of stone units.

1. Show locations and details of joints both within dimension stone cladding assembly and between dimension stone cladding assembly and other construction.
2. Include details of mortar joints, sealant joints, and mortar joints pointed with sealant.
3. Show locations and details of anchors and backup structure.
4. Show direction of veining, grain, or other directional pattern.
5. Include large-scale shaded elevations and details of decorative surfaces and inscriptions.

D. Samples for Initial Selection: For joint materials involving color selection.

E. Stone Samples for Verification: Sets for each variety, color, and finish of stone required; not less than 12 inches square.

1. Sets shall consist of at least four Samples, exhibiting extremes of the full range of color and other visual characteristics expected and will establish the standard by which stone will be judged.

F. Colored Pointing Mortar Samples for Verification: For each color required. Make Samples using same sand and mortar ingredients to be used on Project.

G. Sealant Samples for Verification: For each type and color of joint sealant required.

H. Delegated-Design Submittal: For dimension stone cladding assembly.

I. Qualification Data: For Installer, fabricator, professional engineer, and testing agency.

J. Welding certificates.

K. Material Test Reports:

1. Stone Test Reports: For each stone variety proposed for use on Project, by a qualified testing agency, indicating compliance with required physical properties, other than abrasion resistance, according to referenced ASTM standards. Base reports on testing done within previous three years.
2. For metal components, by a qualified testing agency, indicating chemical and physical properties of metal.
3. Sealant Compatibility and Adhesion Test Report: From sealant manufacturer complying with requirements in Section 07900 "Joint Sealants" and indicating that sealants will not stain or damage stone. Include interpretation of test results and recommendations for primers and substrate preparation needed for adhesion.

L. Preconstruction test reports.

M. Source quality-control reports.

N. Cold-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with cold-weather requirements.

1.06 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Dimension Stone Units: Furnish 4 finished stone panels <**Insert required dimensions**> for each finish and variety of stone specified.

1.07 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate dimension stone cladding assemblies similar to that required for this Project and whose products have a record of successful in-service performance.

B. Installer Qualifications: A firm or individual experienced in installing dimension stone cladding assemblies similar in material, design, and extent to that indicated for this Project, whose work has a record of successful in-service performance.

C. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel and AWS D1.3, "Structural Welding Code - Sheet Steel."

E. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of typical exterior wall area as shown on Drawings.
   a. Include typical components, attachments to building structure, and methods of installation.
   b. Include window opening with stone returns, trim.
   c. Include sealant-filled joint complying with requirements in Section 07900 "Joint Sealants."
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.08 PRECONSTRUCTION TESTING

A. Preconstruction Stone Testing: [Owner will engage] [Engage] a qualified independent testing agency to perform preconstruction testing.

1. Retesting of materials that fail to meet specified requirements shall be done at Contractor's expense.
2. Furnish test specimens that are representative of materials proposed for incorporation into the Work.
3. Physical Property Tests: For each stone variety proposed for use on Project, tested for compliance with physical property requirements, other than abrasion resistance, according to referenced ASTM standards.
4. Flexural Strength Tests: For each combination of] stone variety, thickness, orientation of cut, and finish, proposed for use on Project, tested according to ASTM C880, in both wet and dry conditions.

5. Anchorage Tests: For each combination of] stone variety, orientation of cut, finish, and anchor type proposed for use on Project, tested according to ASTM C1354.

6. Anchoring System Mockup Test: For stone anchoring system, tested according to ASTM C1201, Procedure B, with a maximum test load equal to 3 times the design load. Build laboratory mockup at testing agency facility; use personnel, materials, and methods of construction that will be used at Project site. Mockup shall consist of one panel not less than 72 inches long by 48 inches high in size.

B. Preconstruction Sealant Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for compatibility and adhesion testing according to sealant manufacturer's standard testing methods and Section 07900 "Joint Sealants" Samples of materials that will contact or affect joint sealants.

C. Preconstruction Field Testing of Sealants: Before installing joint sealants, field test their adhesion to joint substrates according to Section 07900 "Joint Sealants."

1.09 DELIVERY, STORAGE, AND HANDLING

A. Store and handle stone and related materials to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping, and other causes.

1. Lift stone with wide-belt slings; do not use wire rope or ropes that might cause staining. Move stone, if required, using dollies with cushioned wood supports.

2. Store stone on wood skids or pallets with nonstaining, waterproof covers. Arrange to distribute weight evenly and to prevent damage to stone. Ventilate under covers to prevent condensation.

B. Mark stone units, on surface that will be concealed after installation, with designations used on Shop Drawings to identify individual stone units. Orient markings on vertical panels so that they are right side up when units are installed.

C. Deliver sealants to Project site in original unopened containers labeled with manufacturer's name, product name and designation, color, expiration period, pot life, curing time, and mixing instructions for multicomponent materials.

D. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

E. Store aggregates in locations where grading and other required characteristics can be maintained and where contamination can be avoided.

1.10 FIELD CONDITIONS

A. Protect dimension stone cladding during erection by doing the following:

1. Cover tops of dimension stone cladding installation with nonstaining, waterproof sheeting at end of each day's work. Cover partially completed structures when work is not in progress. Extend cover a minimum of 24 inches down both sides and hold securely in place.

2. Prevent staining of stone from mortar, grout, sealants, and other sources. Immediately remove such materials without damaging stone.

3. Protect base of walls from rain-splashed mud and mortar splatter by coverings spread on ground and over wall surface.

4. Protect sills, ledges, and projections from mortar and sealant droppings.

B. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Remove and replace dimension stone cladding damaged by frost or freezing conditions. Comply with cold-weather construction and protection requirements for masonry contained in ACI 530.1/ASCE 6/TMS 602.

C. Hot-Weather Requirements: Comply with hot-weather construction and protection requirements for masonry contained in ACI 530.1/ASCE 6/TMS 602.

D. Environmental Limitations for Sealants: Do not install sealants when ambient and substrate temperatures are outside limits permitted by sealant manufacturer or below 40 deg F or when joint substrates are wet.

1.11 COORDINATION

A. Coordinate installation of inserts that are to be embedded in concrete or masonry, flashing reglets, and similar items to be used by dimension stone cladding Installer for anchoring, supporting, and flashing of dimension stone cladding assembly. Furnish setting drawings, templates, and directions for installing such items and deliver to Project site in time for installation.

B. Time delivery and installation of dimension stone cladding to avoid extended on-site storage and to coordinate with work adjacent to dimension stone cladding.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Source Limitations for Stone: Obtain stone, regardless of finish, from single quarry, whether specified in this Section or in another Section of the Specifications, with resources to provide materials of consistent quality in appearance and physical properties.

1. For stone types that include same list of varieties and sources, provide same variety from same source for each.

2. Make quarried blocks available for examination by Architect.

B. Source Limitations for Mortar Materials: Obtain mortar ingredients of uniform quality for each cementitious component from single manufacturer and each aggregate from single source or producer.

C. Source Limitations for Other Materials: Obtain each type of stone accessory**,** sealant**,** and other material from single manufacturer for each product.

2.02 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Division 01, "General Requirements," to design dimension stone cladding assembly.

B. General: Design stone anchors and anchoring systems according to ASTM C1242 “Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems.”

1. Stone anchors shall withstand not less than two times the weight of the stone cladding in both compression and tension.

C. Structural Performance: Dimension stone cladding assembly shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Wind Loads: As indicated.

2. Equipment Loads: Allow for loads due to window cleaning and maintenance equipment.

D. Seismic Performance: Dimension stone cladding assembly shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Component Importance Factor: 1.5.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

F. Horizontal Building Movement (Interstory Drift): Allow for maximum horizontal building movement equal to quotient resulting from dividing floor-to-floor height at any floor by 400.

G. Shrinkage and Creep: Allow for progressive vertical shortening of building frame equal to 1/8 inch in 10 feet.

H. Safety Factors for Stone: Design dimension stone cladding assembly to withstand loads indicated without exceeding stone's allowable working stress determined by dividing stone's average ultimate strength, as established by testing, by the following safety factors:

1. Safety Factor for Granite: [**3**].

2. Safety Factor for Concentrated Stresses: [**4**] for granite.

I. Design stone anchors and backup structure to withstand loads indicated without exceeding allowable working stresses established by the following:

1. For Structural Steel: AISC 360.

2. For Cold-Formed Steel: AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

3. For Cold-Formed Stainless Steel: ASCE 8, "Specification for the Design of Cold-Formed Stainless Steel Structural Members."

4. For Aluminum: AA ADM-1, "The Aluminum Design Manual."

5. For Cast-in-Place and Post-installed Fasteners in Concrete: One-fourth of tested capacity when installed in concrete with compressive strength indicated.

J. Limit deflection in each prefabricated assembly caused by indicated loads and thermal movements, acting singly or in combination with one another, to not more than [**1/720**] of assembly's clear span or the following, whichever is smaller:

1. 1/16 inch, measured in plane of wall.

2. 1/4 inch, measured perpendicular to wall.

K. Provisions for Fabrication and Erection Tolerances: Allow for fabrication and erection tolerances of building's structural system. [Concrete fabrication and erection tolerances are specified in Section 03300 "Cast-in-Place Concrete."] [Structural-steel fabrication and erection tolerances are specified in Section 05120 "Structural Steel Framing."]

L. Provision for Deflection of Building Structure:

1. Deflection Due to Weight of Dimension Stone Cladding Assembly: Allow for [**1/4-inch**] vertical deflection in 20-foot span of structural members supporting dimension stone cladding assembly.

2. Live Load Deflection: Allow for 1/4-inch vertical deflection, in 20-foot span of structural members supporting dimension stone cladding assembly, due to live loads imposed on building's structural frame after stone installation.

M. Corrosion and Staining Control: Prevent galvanic and other forms of corrosion as well as staining by isolating metals and other materials from direct contact with incompatible materials. Materials shall not stain exposed surfaces of stone and joint materials.

2.03 STONE

A. Stone Type 1: Granite as specified in Section 04415 “Granite”.

B. Stone Type 2: As indicated on the drawings.

C. Material Standard: Comply with ASTM C615.

D. Regional Materials: Granite shall be fabricated within 500 miles of Project site from stone that has been extracted within 500 miles of Project site.

E. Cut stone from one block or contiguous, matched blocks in which natural markings occur.

F. Finish: As specified in Section 04415, “Granite”.

1. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.

G. Thickness: Not less than 1-1/2 inches unless otherwise indicated or as required to meet performance requirements.

2.04 ANCHORS AND FASTENERS

A. Fabricate anchors, including shelf angles, from stainless steel, ASTM A240 or ASTM A666, Type 316; temper as required to support loads imposed without exceeding allowable design stresses. Fabricate dowels and pins for anchors from stainless steel, ASTM A276, Type 316.

B. Fabricate anchors, including shelf angles, from extruded aluminum, ASTM B221, alloy and temper as required to support loads imposed without exceeding allowable design stresses, but not less than strength and durability properties of Alloy 6063-T6.

C. Cast-in-Place Concrete Inserts: Either threaded or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47 malleable iron or ASTM A27 cast steel, with capability to sustain, without failure, a load equal to 4 times the loads imposed as determined by testing per ASTM E488, conducted by a qualified independent testing agency. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329.

D. Postinstalled Anchor Bolts for Concrete and Masonry: [Chemical anchors] [torque-controlled expansion anchors] [or] [undercut anchors] made from stainless-steel components complying with ASTM F593 and ASTM F594, Alloy Group 1 or 2 for bolts and nuts; ASTM A240, ASTM A276, or ASTM A666, Type 304 or 316, for anchors, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

E. Threaded Fasteners: Heavy hexagon structural bolts, heavy hexagon nuts, and hardened washers.

1. For stainless steel, use annealed stainless-steel bolts, nuts, and washers; for bolts, ASTM F593; and for nuts, ASTM F594, Alloy [Group 1] [Group 2].

2. For [galvanized-steel shelf angles] [and] [backup structure], use carbon-steel bolts, nuts, and washers; for bolts, ASTM A307, Grade A; for nuts, ASTM A563, Grade A; and for washers, ASTM F436; all hot-dip or mechanically zinc coated.

F. Weld Plates for Installation in Concrete: Comply with Section 05500 "Metal Fabrications."

2.05 MORTAR MATERIALS

A. Portland Cement: ASTM C150, Type I or Type II, except Type III may be used for cold-weather construction, natural color or white as required to produce mortar color indicated.
1. Low-Alkali Cement: Portland cement for use with limestone shall contain not more than 0.60 percent total alkali when tested according to ASTM C114.

B. Hydrated Lime: ASTM C207.

C. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C979. Pigments shall have a record of satisfactory performance in mortar.

D. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime.

E. Colored Portland Cement-Lime Mix: Packaged blend of portland cement, hydrated lime, and mortar pigments. Mix shall produce color indicated or, if not indicated, as selected from manufacturer's standard colors. Pigments shall not exceed 10 percent of portland cement by weight.

F. Aggregate: ASTM C144; except for [joints narrower than 1/4 inch] [and] [pointing mortar], 100 percent shall pass No. 16 sieve.

1. White Aggregates: Natural white sand or ground white stone.

2. Colored Aggregates: Natural-colored sand or ground marble, granite, or other durable stone; of color necessary to produce required mortar color.

G. Water: Potable.

2.06 STONE ACCESSORIES

A. Setting Shims: Strips of [resilient plastic] [or] [vulcanized neoprene, Type A Shore durometer hardness of 50 to 70], nonstaining to stone, of thickness needed to prevent point loading of stone on anchors and of depths to suit anchors without intruding into required depths of pointing materials.

B. Setting Buttons: Resilient plastic buttons, nonstaining to stone, sized to suit joint thicknesses and bed depths of stone units without intruding into required depths of pointing materials.

C. Concealed Sheet Metal Flashing: Fabricated from stainless steel in thicknesses indicated, but not less than 0.0156 inch thick, and complying with Section 07620 "Sheet Metal Flashing and Trim."

D. Cementitious Dampproofing: Cementitious formulation recommended by ILI and nonstaining to stone; compatible with joint sealants and noncorrosive to anchors and attachments.

E. Weep and Vent Tubes: [Medium-density polyethylene tubing, 1/4-inch OD] [Rectangular, cellular, polypropylene or clear butyrate extrusion, 3/8 by 1-1/2 inches], of length required to extend from exterior face of stone to cavity behind.

F. Wicking Material: Absorbent rope, made from [cotton] [or] [UV-resistant synthetic fiber], 1/4 to 3/8 inch in diameter, of length required to produce 2-inch exposure on exterior and 18 inchesin cavity between wythes.

G. Sealants for Joints in Dimension Stone Cladding: Manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated below that comply with applicable requirements in Section 07900 "Joint Sealants" and do not stain stone:

1. Silicone Joint Sealant: [Single component, nonsag, neutral curing, Class 100/50] [Single component, nonsag, neutral curing, Class 50] [Single component, nonsag, neutral curing, Class 25] [Single component, nonsag, acid curing] [Multicomponent, nonsag, neutral curing].
2. Urethane Joint Sealant: [Single component, nonsag, Class 100/50] [Single component, nonsag, Class 50] [Single component, nonsag, Class 25] [Multicomponent, nonsag, Class 50] [Multicomponent, nonsag, Class 25].
3. Preformed Joint Sealant: Preformed [silicone] [foam].
4. Joint-Sealant Colors: Match Architect's sample] [As selected by Architect from manufacturer's full range of colors] [Match color of stone].

H. Sealant for Filling Kerfs: [Same sealant used for joints in dimension stone.] [Manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated below that comply with applicable requirements in Section 07900 "Joint Sealants" and that do not stain stone:]

1. Single-component, nonsag, neutral-curing, medium- to high-modulus silicone sealant; Class 25, Use NT (nontraffic), and Use M (masonry).
2. Single-component, nonsag, urethane sealant; Class 25, Use T (traffic), and Use M (masonry).

2.07 STONE FABRICATION

A. General: Fabricate stone units in sizes and shapes required to comply with requirements indicated.

1. For granite, comply with recommendations in NBGQA's "Specifications for Architectural Granite."

B. Control depth of stone and back check to maintain minimum clearance of 1 inch between backs of stone units and surfaces or projections of structural members, fireproofing (if any), backup walls, and other work behind stone.

C. (bed and vertical) straight and at right angle to face unless otherwise indicated. Shape beds to fit supports.

D. Cut and drill sinkages and holes in stone for anchors, fasteners, supports, and lifting devices as indicated or needed to set stone securely in place.

E. Finish exposed faces and edges of stone[**,** except sawed reveals**,**] to comply with requirements indicated for finish and to match approved samples and mockups.

F. Quirk-miter corners unless otherwise indicated; provide for cramp anchorage in top and bottom bed joints of corner pieces.

G. Cut stone to produce uniform joints [**3/8 inch**] [**1/2 inch**] wide and in locations indicated.

H. Contiguous Work: Provide chases, reveals, reglets, openings, and similar features as required to accommodate contiguous work.

I. Fabricate molded work, including washes and drips, to produce stone shapes with a uniform profile throughout entire unit length, with precisely formed arris slightly eased to prevent snipping, and with matching profile at joints between units.

1. Produce moldings and molded edges with machines that use abrasive shaping wheels made to reverse contour of molding shape.

J. Clean backs of stone to remove rust stains, iron particles, and stone dust.

K. Inspect finished stone units at fabrication plant for compliance with requirements for appearance, material, and fabrication. Replace defective units.

1. Grade and mark stone for overall uniform appearance when assembled in place. Natural variations in appearance are acceptable if installed stone units match range of colors and other appearance characteristics represented in approved samples and mockups.

2.08 SHOP-PAINTED STEEL FINISHES

A. General: Paint uncoated steel backup structure before delivering to Project site to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel."

B. Surface Preparation: After fabricating steel items, prepare surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

C. Apply one coat of fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#76.[After primer has dried, apply one coat of exterior alkyd enamel complying with MPI#96 of a different color than primer.]

D. Apply two-coat, high-performance coating system consisting of epoxy zinc-rich primer, complying with MPI#20 and topcoat of high-build epoxy coating, complying with MPI#108.

2.09 MORTAR MIXES

A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures needed to produce mortar of uniform quality and with optimum performance characteristics.

1. Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated. Do not use calcium chloride.

2. Combine and thoroughly mix cementitious materials, water, and aggregates in a mechanical batch mixer unless otherwise indicated. Discard mortar when it has reached initial set.

B. Portland Cement-Lime Setting Mortar: Comply with ASTM C270, Proportion Specification, for types of mortar indicated below:

1. Set granite with Type S mortar.

C. Pointing Mortar: Comply with ASTM C270, Proportion Specification, for types of mortar indicated. Provide pointing mortar mixed to match Architect's sample and complying with the following:

1. Pigmented Pointing Mortar: Select and proportion pigments with other ingredients to produce color required. Do not exceed pigment-to-cement ratio of 1:10, by weight.

2. Packaged Portland Cement-Lime Mix Mortar: Use portland cement-lime mix of selected color.

3. Point granite with Type S mortar.

2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform source quality-control testing.

1. Retesting of materials that fail to meet specified requirements shall be done at Contractor's expense.

2. Furnish test specimens [randomly selected] [selected by testing agency] from same blocks as actual materials proposed for incorporation into the Work.

3. Flexural Strength Tests: ASTM C880, performed on specimens of same thickness, orientation of cut, and finish as installed stone. One set of test specimens is required to be tested for every 3000 sq. ft., but not fewer than two sets for each stone variety.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces to receive dimension stone cladding and conditions under which dimension stone cladding will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of dimension stone cladding.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of dimension stone cladding.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 SETTING DIMENSION STONE CLADDING, GENERAL

A. Before setting stone, clean surfaces that are dirty or stained by removing soil, stains, and foreign materials. Clean stone by thoroughly scrubbing with fiber brushes and then drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh materials or abrasives.

B. Execute dimension stone cladding installation by skilled mechanics and employ skilled stone fitters at Project site to do necessary field cutting as stone is set.

1. Use power saws with diamond blades to cut stone. Produce lines cut straight and true, with edges eased slightly to prevent snipping.

C. Contiguous Work: Provide reveals, reglets, and openings as required to accommodate contiguous work.

D. Set stone to comply with requirements indicated. Install anchors, supports, fasteners, and other attachments indicated or necessary to secure dimension stone cladding in place. Shim and adjust anchors, supports, and accessories to set stone accurately in locations indicated, with uniform joints of widths indicated, and with edges and faces aligned according to established relationships and indicated tolerances.

E. Provide expansion, control, and pressure-relieving joints of widths and at locations indicated.

1. Sealing expansion and other joints is specified in Section 07900 "Joint Sealants."

2. Keep expansion joints free of mortar and other rigid materials.

F. Install concealed flashing at continuous shelf angles, lintels, ledges, and similar obstructions to downward flow of water, to divert water to building exterior. Extend flashing 6 inches at ends and turn up not less than 2 inches to form end dams.

G. Keep cavities open where unfilled space is indicated between back of stone units and backup wall; do not fill cavities with mortar or grout.

1. Place weep holes in joints where moisture may accumulate, including at base of cavity walls and above shelf angles and flashing. Locate weep holes at intervals not exceeding 24 inches. Use [weep and vent tubes] [plastic weep hole/vents] [or] [wicking material].

2. Place vents in cavity walls at tops of cavities, below shelf angles and flashing, and at intervals not exceeding 20 feet vertically. Locate vents in joints at intervals not exceeding 60 inches horizontally. Use [weep and vent tubes] [or] [plastic weep hole/vents].

3.03 SETTING MECHANICALLY ANCHORED DIMENSION STONE CLADDING

A. Set dimension stone cladding with mechanical anchors without mortar unless otherwise indicated.

B. Attach anchors securely to stone and to backup surfaces. Comply with recommendations in ASTM C1242.

C. Provide compressible filler in ends of dowel holes and bottoms of kerfs to prevent end bearing of dowels and anchor tabs on stone. Fill remainder of anchor holes and kerfs with sealant indicated for filling kerfs.

D. Set stone supported on clips or continuous angles on resilient setting shims. Use material of thickness required to maintain uniform joint widths and to prevent point loading of stone on anchors. Hold shims back from face of stone a distance at least equal to width of joint.

3.04 SETTING DIMENSION STONE CLADDING WITH MORTAR

A. Set dimension stone cladding with mortar and mechanical anchors unless otherwise indicated.

B. Set stone in full bed of mortar with head joints filled unless otherwise indicated.

1. Use setting buttons of adequate size, in sufficient quantity, and of thickness required to maintain uniform joint width and to prevent mortar from extruding. Hold buttons back from face of stone a distance at least equal to width of joint, but not less than depth of pointing materials.
2. Do not set heavy units or projecting courses until mortar in courses below has hardened enough to resist being squeezed out of joint.
3. Support and brace projecting stones until wall above is in place and mortar has set.
4. Provide compressible filler in ends of dowel holes and bottoms of kerfs to prevent end bearing of dowels and anchor tabs on stone. Fill remainder of anchor holes and kerfs with mortar.

C. Fill space between back of stone units and backup wall solidly with mortar or grout.

D. Embed ends of sills in mortar; leave remainder of joint open until final pointing.

E. Rake out joints for pointing with mortar to depths of not less than 1/2 inch. Rake joints to uniform depths with square bottoms and clean sides.

F. Prepare stone-joint surfaces for pointing with mortar by removing dust and mortar particles. Where setting mortar was removed to depths greater than surrounding areas, apply first layer of pointing mortar in layers not more than 3/8 inch until a uniform depth is formed.

G. Point stone joints by placing pointing mortar in layers not more than 3/8 inch. Compact each layer thoroughly and allow to become thumbprint hard before applying next layer.

H. Tool joints with a round jointer having a diameter 1/8 inch larger than width of joint, when pointing mortar is thumbprint hard.

I. Rake out mortar from sealant-pointed joints to depths required for sealant and sealant backing but not less than 1/2 inch. Rake joints to uniform depths with square bottoms and clean sides.

J. Set the following dimension stone cladding with unfilled head joints for installing joint sealants:

1. Cornices.
2. Copings.
3. Sills.
4. Belt and other projecting courses.

3.05 JOINT-SEALANT INSTALLATION

A. Prepare joints and apply sealants of type and at locations indicated to comply with applicable requirements in Section 07900 "Joint Sealants."

3.06 INSTALLATION TOLERANCES

A. Variation from Plumb: For vertical lines and surfaces of walls, do not exceed 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2 inch in 40 feet or more. For external corners, corners and jambs within 20 feet of an entrance, expansion joints, and other conspicuous lines, do not exceed 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 3/8 inch in 40 feet or more.

B. Variation from Level: For lintels, sills, water tables, parapets, horizontal bands, horizontal grooves, and other conspicuous lines, do not exceed 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 3/8 inch maximum.

C. Variation of Linear Building Line: For positions shown in plan and related portions of walls and partitions, do not exceed 1/4 inch in 20 feet or 1/2 inch in 40 feet or more.

D. Variation in Cross-Sectional Dimensions: For thickness of walls from dimensions indicated, do not exceed plus or minus 1/4 inch.

E. Variation in Joint Width: Do not vary from average joint width more than plus or minus 1/8 inch or a quarter of nominal joint width, whichever is less. For joints within 60 inches of each other, do not vary more than 1/8 inch or a quarter of nominal joint width, whichever is less from one to the other.

F. Variation in Plane between Adjacent Stone Units (Lipping): Do not exceed 1/16-inch difference between planes of adjacent units.

3.07 ADJUSTING AND CLEANING

A. Remove and replace broken, chipped, stained, or otherwise damaged stone, defective joints, and dimension stone cladding that does not match approved samples and mockups. Damaged stone may be repaired if Architect approves methods and results.

B. Replace damaged or defective work in a manner that results in dimension stone cladding's matching approved samples and mockups, complying with other requirements, and showing no evidence of replacement.

C. In-Progress Cleaning: Clean dimension stone cladding as work progresses. Remove mortar fins and smears before tooling joints. Remove excess sealant and smears as sealant is installed.

D. Final Cleaning: Clean dimension stone cladding no fewer than six days after completion of pointing and sealing, using clean water and stiff-bristle fiber brushes. Do not use wire brushes, acid-type cleaning agents, cleaning agents containing caustic compounds or abrasives, or other materials or methods that could damage stone.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies structural steel work.

B. Options:
1. Substitution of rolled shapes for welded sections and vice versa is permitted, provided that shapes and sections to be substituted are approved and comply with the following:
   a. Keep depth, width, average or mean thickness, web shear area, moments of inertia, torsional constant and warping constant to be at least equal to those for shape or section shown. Maintain clearances and other dimensions shown as critical.
   b. Have steel shapes, plates and bars conform to same ASTM designation as material for which substitution is made.

C. Related Work Specified Elsewhere:
1. Finish painting for structural steel: Section 09920.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: D1.1.
3. AASHTO: Interim 1981 Fracture Control Plan; Standard Specifications for Highway Bridges, including supplements. Where conflict occurs between AWS and AASHTO, AASHTO governs.
4. AISC:
   a. Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design.
   b. Manual of Steel Construction-Allowable Stress Design.
   c. Code of Standard Practice for Steel Buildings and Bridges.
   d. Allowable Stress Design Specification for Structural Joints using ASTM A325 or A490 Bolts.
   e. Specifications for Architecturally Exposed Structural Steel.
5. ASNT: Recommended Practice SNT-TC-1A.
6. SSPC: SP-6, SP-10.
7. ANSI: B27.2.
8. MS: MIL-P-21035.
9. FS: TT-P-645
10. ASTM: A6, A27, A36, A108, A109, A123, A148, A153, A242, A307, A325, A370, A449, A490, A500, A501, A514, A517, A572/572M, A588, A668, A673, A709, A780, B663, B766.

B. Source Quality Control:
1. Testing and inspection:
   a. Nondestructive-test requirements for welded members:
      1) Perform the following:

2) Tension butt welds in fracture-critical nonredundant members and member components of structures subject to repetitive dynamic loading: 100 percent of welds inspected by radiographic and ultrasonic examination.
3) Butt welds of flange material for compression and tension splices: 100 percent of welds inspected by ultrasonic examination.
4) Butt welds for web splices beginning at point of maximum stress: 40 percent of welds inspected by ultrasonic examination.
5) Fillet welds connecting web plates to flange plates: 25 percent of welds inspected by magnetic particle inspection.
6) For all other fillet-weld connections: 10 percent of welds inspected by magnetic particle inspection.
7) The Engineer may designate additional items to be inspected by radiography.

b. Mill testing:
1) For identified stock materials provide three specimens from each heat number, one for tension test, one for bend test and one for Charpy V-notch impact test.
2) Cut, machine and test specimens in accordance with ASTM A370.
3) Perform Charpy V-notch impact test for tension flanges and other tension components of aerial structures in accordance with Table 05120-1.

c. Bolts:
1) The Engineer will randomly select at least five bolts for test purposes from each bin of bolts furnished.

C. Qualification of Welding Personnel and Procedures:
1. Prior to qualifying welding personnel and welding procedures, confirm an agreement with the Engineer as to procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment.
2. Employ welding personnel whose qualification is certified in accordance with AWS D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.
3. Do not start fabrication until qualification has been successfully completed.

D. Qualification of Nondestructive-Testing Personnel:
1. Nondestructive testing of fracture-critical members to be conducted by personnel qualified as NDT Level II or Level III in accordance with ASNT SNT-TC-1A.
2. Level-II technicians to be supervised by Level III-personnel.

E. Stock Material:
1. For qualification of welding personnel and procedures and for quality-assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.
2. When stock material is proposed, inform the Engineer of such intention at least 10 days in advance of commencing fabrication to permit sampling and testing. Select identified material from as few heats as possible.

F. Welder's Identification Mark (for Fabrication Shops):
1. Assign each welder and welding operator an identification mark to stamp on pieces he has welded.
2. Have welder or welding operator place his identification mark by metal-die stamp in letters 3/8-inch high in position that identification of welder or operator will appear

adjacent to each of his welds in finally assembled members for ready reference to radiographic films and for identification by the Engineer.

G. Elevator Hoistways:
1. Fabricate framing not to exceed 1/8-inch deviation from dimensions shown throughout. Perform straightening where necessary.

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings:
1. Structural details: Include the following:
a. Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.
b. Details of location, type, sizes of bolts and welds and for welded structures details of welding as specified.
c. Structural computations for Contractor-designed work certified by a professional engineer registered in the jurisdiction where the work is to be performed.
2. Match marks:
a. Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.
3. Welding:
a. Complete shop details of qualification test specimens.
b. Include information on specimen identification, number of pieces and welding procedure specification, type of material, sizes of pieces and welds and other variables affecting detail or tests.
4. Erection Plan:
a. Details of methods of erection proposed to be used, including calculated stresses for proposed erection certified by a professional engineer registered in the jurisdiction where the work will be performed. Do not proceed until approval has been received.
5. Manufacturer's test procedures for bolts.

B. Certification:
1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.
2. Certified quality-assurance testing and inspection reports.
3. Certification verifying that welding personnel have been qualified in accordance with AWS D1.1 and as specified above under Qualifications of Welding Personnel and Procedures.
4. Manufacturer's certification that bolts meet approved testing.
5. Certification of nondestructive-testing personnel.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. General:
1. Load, transport, unload and store structural materials so as to keep them clean and free from damage.
2. Store material on platforms, skids or other supports above the ground and ensure proper drainage and protection from corrosion.

B. Steelwork:
   1. When handling and shipping steelwork, prevent bending, scraping or over stressing members.
   2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material
   3. Replace pieces bent or damaged unless repair is approved.
   4. Indicate weight on members weighing more than three tons by means of paint contrasting with shop coat.

C. Bolts and Nuts:
   1. Ship small parts such as bolts, nuts, washers, pins, fillers and small connecting plates or angles in boxes, crates or barrels.
   2. Pack separately bolts of each length and diameter and loose nuts or washers of each size.

D. Paint:
   1. Have paint materials delivered in manufacturer's original sealed containers, bearing manufacturer's label and name, specification identification number where applicable as well as month and year of manufacture.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
   1. Welding:
      a. When welding during cold weather, avoid chilling weld metal within zone of welding influence and avoid restraining manual functions of welder or welding operator.
      b. When temperature where steel is stored is more than 20F below that of welding shop, move steel to be welded into shop sufficiently in advance of welding to allow it to attain shop temperature prior to welding.
      c. Steel to be free of moisture. Dry as necessary by application of heat not exceeding 100F.
      d. Do not weld when shop temperature is below 40F.
   2. Painting:
      a. Apply paint when temperature of steel and paint is above 40F and temperature is forecast to remain above 40F until paint has dried.
      b. Painting steel at a temperature which can cause blistering, porosity or conditions otherwise detrimental to life of paint is prohibited. When paint is applied in hot weather or thinned in cold weather, ensure that specified thickness of paint coating is obtained.
      c. Application of paint in rain, wind, snow, fog or mist or when steel surface temperature is below dew point is prohibited, unless otherwise approved. If painting in damp or cold weather is unavoidable, provide protective covering and heat steel and surrounding air to 40F minimum. Maintain this temperature until weather conditions permit discontinuance.

PART 2- PRODUCTS

2.01 MATERIALS:

A. General Requirements for Rolled-Steel Plates, Shapes and Bars: ASTM A6.

B. Carbon-Steel Plates, Shapes and Bars: ASTM A36, ASTM A709, Grade 36.

C. High-Strength, Low-Alloy, Structural-Steel Plates, Shapes and Bars: ASTM A242.

D. High-Strength, Low-Alloy, Structural, Columbium-Vanadium Structural Steel: ASTM A572/A572M.

E. Corrosion-Resistant Structural Steel: ASTM A242., A588

F. High-Strength, Low-Alloy, Corrosion-Resistant Structural-Steel Shapes, Plates, and Bars: ASTM A588.

G. Low-Carbon Steel Bolts and Nuts: ASTM A307, Grade A or B.

H. High-Strength Carbon-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A325; for bolts over one-inch diameter, ASTM A449.

I. High-Strength Alloy-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A490.

J. Round Washers Other Than Those In Contact With High-Strength Bolt Heads And Nuts: ANSI B27.2, Type B.

K. Beveled Washers:
   1. Square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
   2. Diameter of hole in square beveled washers as follows:
      a. For bolts less than one-inch diameter: 1/16-inch larger than bolt size.
      b. For bolts larger than one-inch diameter: 1/8-inch larger than bolt size.

L. Carbon-Steel Forgings: ASTM A668, Class C.

M. Alloy-Steel Forgings: ASTM A668, Class G.

N. Structural-Steel Tubing:
   1. Structural framing for elevator hoistways: ASTM A500, Grade B.
   2. Other structural tubing: ASTM A501.

O. High-Strength Steel Casting: ASTM A148, metal type as shown.

P. Mild-To-Medium-Strength Carbon-Steel Castings: ASTM A27, grade as shown.

Q. Shear Connectors:
   1. Cold-rolled carbon-steel strip.
   2. Stud-welding fasteners with upset head developing tensile strength of 65,000 psi-minimum and yield strength of 52,000-psi minimum.
   3. Complying otherwise to the following:
      a. Cold-finished bars, Grade 1015, Grade 1018 or Grade 1020, semi-killed or fully killed: ASTM A108.
      b. Low-carbon steel suitable for welding: ASTM A109.
   4. Stud welding conforming to AWS D1.1.
   5. Sizes and shapes: As shown.
   6. Lengths to be after-weld lengths.
   7. Studs arc-welded to parent metal as shown.
   8. Before welding, parent-metal surface to be free from rust, oil, paint, plating and other foreign matter.
   9. Heat treat parent metal where needed to develop full weld strength.

R. Galvanizing:

1. Steel products specified as galvanized to be hot-dip galvanized after fabrication in accordance with the following:
    a. Zinc coatings on products fabricated from rolled, dressed and forged steel shapes, plates and strips: ASTM A123.
    b. Zinc coating on iron and steel hardware: ASTM A153.
    c. Zinc coating on assembled steel products: ASTM A123.
    d. Zinc-coating weight: Two ounces per square foot minimum.
    e. Zinc-dust zinc-oxide primer conforming to MS MIL-P-21035 applied in accordance with ASTM A780 in two coats for repairs to damaged surfaces after removal of loose or cracked zinc coating.

S. Electroplated Zinc Coating: ASTM B663 for type specified.

T. Cadmium Plating: ASTM B766 for type specified.

U. Paint for Shop Prime Coating: FS TT-P-645.

V. Cleaning Solution: Muriatic acid solution, specific gravity 1.18, prepared in a solution of one-part muriatic acid and five parts water.

PART 3 - EXECUTION

3.O1 FABRICATION:

A. Workmanship and finish to best commercial practice accomplished in structural or bridge shops.

B. Straightening Material:
1. Use rolled material that, before being laid off or worked, is straight within tolerances specified in ASTM A6.
2. Perform straightening where necessary by approved methods which will not overstress material.
3. Do not heat-shrink low-alloy structural steel.
4. Achieve fabrication tolerances which will result in full bearing.
5. Perform straightening, planing and connecting of portions of members in bearing assemblies and in direct bearing after fabrication as necessary to provide full bearing assemblies and bearing areas.

C. Cutting:
1. Flame-cut edges of members subject to dynamic loading by mechanically guided torch or by hand. Remove nicks by grinding to depth not exceeding 1/4 inch.
2. Shape re-entrant corners notch-free to radius of 1/2-inch minimum.
3. Perform flame cutting so that metal does not carry stress during cutting operation.
4. Direct flame so that remaining material is not damaged.

D. Planing and Facing:
1. Plane to depth of 1/4 inch sheared edges of plates more than 5/8-inch thick which will carry calculated stress.
2. Face and bring abutting joints to even bearing where shown.
3. Fabricate floor beams, stringers and girders having end connection angles to exact length back-to-back of connection angles.
4. For compression joints depending on contact, prepare bearing surfaces to a common plane by milling, sawing or other approved means.

5. Where end connections are faced, ensure that finished thickness of angle is not less than that shown.

E. Bolt Holes:
1. Punch or drill holes for bolts.
2. Subpunch or subdrill and ream assemblies using steel template for alignment of connections as necessary. Flame cutting is prohibited.
3. Subdrill or subpunch holes 3/16-inch less than nominal diameter of bolt; drill or ream holes 1/16-inch greater than nominal diameter of bolt.

F. Connections:
1. Except where welded or ASTM A307 bolted connections are shown, use ASTM A325 or ASTM A490 bolts for shop connections.
2. Unless otherwise shown, bolt field connections using ASTM A325 or ASTM A490 bolts in accordance with AISC Specifications for Structural Joints.
3. Use of ASTM A490 bolts for dynamic or fluctuating loadings is prohibited.

G. Plates:
1. Bent plates: For load carrying cold-bent plates, use identified stock and arrange direction of bending at right angles to direction of rolling. Ensure radius of bend, measured on concave face of metal, is not less and preferably more than the following:

Angle of Plate Bend in Degrees	Minimum Radius
61 - 90	1.0T*
91 - 120	1.5T*
121 - 150	2.0T*

*T = Plate thickness.

2. Sheared plates: For gusset plates or connection plates, use sheared plates designed to resist applied loads in more than one direction in plane of plate.

3.02 WELDING:

A. Perform welding in accordance with AWS D1.1.

B. Perform procedure and sequence of welding so as to avoid needless distortion and to minimize stresses. Straighten transverse warpage of flanges, if necessary, by controlled heating along outside face.

C. Make allowance in shop for expected weld shrinkage in laying out and assembling members. Trim members to size when most or all of welding has been completed.

D. Complete butt welds in flange joints before flanges are assembled on web. Use extension blocks on such joints when making ends of butt welds, removing extension blocks only upon completion and cooling of weld. Ensure ends of welds are finished smooth and flush with edges of abutting parts. Use double-V-flange butt welds, unless otherwise shown. Back puddle all end craters.

E. Make welds in web plates where shown.

F. Prior to ultrasonic or radiographic testing of butt welds of flanges and webs, grind or machine weld reinforcement of joint to remove irregularities of weld surface so that it merges smoothly with base surface; one side for ultrasonic testing and both sides for radiographic testing.

G. Ensure that welded joints which are to be radiographed are free of paint, scale and grease. Grind off welded ripples and surface irregularities on both sides of joint. Grind perpendicular to length of weld and to such a degree that resulting radiographic contrast due to remaining irregularities cannot mask or be confused with that of objectionable defect and so that weld surface will merge smoothly into adjoining surface.

H. Repair defective welds by chipping or melting out such defects from one or both sides of joint removing no more weld metal than necessary to correct defect. Reweld and have weld retested radiographically.

I. Welded Structures Subjected to Dynamic Loads:

1. Do not use backup bars for fracture-critical nonredundant members or member components, as defined by AASHTO on Interim 1981 Fracture Control Plan.
2. Avoid use of backup bars elsewhere, unless explicitly permitted by original design.
3. When use of backup bars is unavoidable because of practicality but not explicitly permitted by original design, remove backup bar after welding is completed and affected surfaces of weld metal and base metal is ground flush. Roughness of ground surfaces to be similar to that of surrounding unaffected plate surface.

3.03 BOLTING:

A. Connections using high-strength steel bolts in accordance with AISC Specifications for Structural Joints using ASTM A325 or ASTM A490 bolts.

B. Assemble high-strength bolted parts so that they fit solidly together when assembled. Do not use gaskets or other compressible materials.

C. Remove scale, dirt, burrs and other defects likely to prevent proper seating when assembling joint surfaces, including those adjacent to washers.

D. Remove oil, paint, lacquer and galvanizing from contact surfaces of friction joints.

E. Use two nuts on unfinished bolts and turned bolts in tension.

F. Tightening Bolts:

1. Tighten ASTM A325 or A490 bolts to bolt tension not less than proof load given in AISC Specifications for Bolts.
2. If approved, tighten by means of properly calibrated wrenches or turn-of-nut method.
3. When tightening, place hardened washer under nut or bolt head, depending on which element is turned in tightening operation.
4. Calibrate torque wrenches daily by tightening bolt assembly in device capable of indicating actual bolt tension.
5. Install three bolts minimum from each lot.
6. Nuts or bolts to be in tightening motion when torque is measured.
7. Adjust power wrenches to cut-out or stall at required tension.

G. Arrange bolts so that heads show in areas exposed to public view.

3.04 SHOP ASSEMBLY:

A. Undertake complete or progressive shop assembly of continuous plate and box girders, rigid frames, bents and towers when shown. Obtain approval of progressive shop-assembly procedure.

B. Clean surfaces of metals in contact with each other with high speed wire brushes before assembling.

C. Assemble parts to line and fit; drill or ream bolt holes while assembled. Hand reaming is prohibited unless approved.

3.05 SHOP PRIME PAINTING:

A. Clean steel surfaces in accordance with SSPC SP-6 or SP-10.

B. Shop Painting:

1. Shop paint structural-steel work which will be left bare in finished structures.
2. Do not shop paint the following:
   a. Surfaces within three inches of joints to be field welded.
   b. Galvanized surfaces and surfaces to be galvanized.
   c. Contact surfaces: Apply rust-inhibitive treatment to such surfaces; remove by means of appropriate solvent prior to assembly.
   d. Surfaces to be encased in concrete or in fire-protection material.
   e. Weathering steel.
3. Use paint-spraying equipment, if approved, with type of spray gun recommended by paint manufacturer for paint being applied.
4. Use brushes of good quality bristle. Nylon brushes and roller coaters are prohibited.
5. Neutralize areas of welding which are to be painted by applying specified cleaning solution. Wash neutralized area thoroughly with clean water and allow to dry before painting.
6. Apply shop prime coat at minimum wet-film thickness of three mils. Give surfaces which will be inaccessible after assembly or erection three coats of paint before assembly.
7. Caulk small cracks, cavities and open seams around stiffeners and connections with pasty mixture of red lead and linseed oil or approved caulking putty and allow to dry before applying full shop coat.
8. Apply stripe coat of paint to edges, corners, bolts, welds and other sharp edges before giving steel full shop coat of paint. Apply stripe coat at least one-inch beyond area to be striped and allow to dry before applying full shop coat.
9. Paint erection marks and weight on each member after shop coat has dried.
10. Complete shop painting and ensure paint has completely dried prior to shipment of steel.

3.06 ERECTION:

A. Install anchor bolts accurately in positions shown.

B. If anchor bolts are cast in substructure masonry during its construction, ensure that each bolt is firmly held in its correct position and elevation by suitable templates.

C. If approval is given for installing anchor bolts in preformed holes or in drilled holes in concrete or masonry, use approved nonshrink, nonstaining grout to secure them in place.

D. Set bearing assemblies to lines and grades shown and adjust to horizontal position shown.

E. Erect steel structures true and plumb following match marks.

F. Use temporary bracing to support loads to which structures may be subjected including erection equipment and their operations. Leave bracing in place as long as safety requires.

G. Report immediately to the Engineer errors in shop fabrication or deformation resulting from handling or transportation which prevent proper erection and fitting of parts.

H. As erection progresses perform sufficient bolting of work to support dead load, wind load and erection load. Perform permanent bolting when enough alignment has been accomplished to ensure that as much of structure as possible will be supported by such fastening work.

I. Ensure that holes are not enlarged and that metal in vicinity of holes is not disturbed by drifting during assembly.

J. Enlargement of holes to accept bolts for connections is prohibited unless approved. Make enlargement by reaming not by burning. Avoid hand reaming.

K. Do not field weld main stress members.

L. Bond premolded elastic filler with adhesive to structural framing at elevator hoistways.

3.07 NONDESTRUCTIVE TESTING OF FIELD WELDS:

A. Perform pertinent testing specified for source quality control.

3.08 FIELD TOUCH-UP PAINTING:

A. Retouch surfaces where shop coat has been damaged using paint and paint-film thickness identical to original shop coat.

B. After erection, clean field bolts, nuts and adjacent areas and apply coat of paint identical to original shop coat.

C. Finish painting for structural steel in accordance with Section 09920.

TABLE 05120-1				
BASE METAL CHARPY V-NOTCH REQUIREMENTS[*a] FOR FRACTURE-CRITICAL MEMBERS				
ASTM	Thickness, Inches (mm)	Zone 1[*b]	Zone 2[*c]	Zone 3[*d]
A36	Up to 4 inches (101.6)	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A572[*e]	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A588[*e]	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Over 2 inches to 4 inches (50.8 to 101.6) welded	30 at 70F (40.7 Nm at 21.1C)	30 at 40F (40.7 Nm at 4.4C)	30 at 10F (40.7 Nm at minus 12.2C)
A514[*f]	Up to 4 inches (101.6) mechanically fastened	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Up to 2-1/2 inches (63.5) welded	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Over 2-1/2 inches to 4 inches (63.5) welded	45 at zero degree F (61.0 Nm at minus 17.8C)	45 at zero degree F (61.0 Nm at minus 17.8C)	Not permitted

[*a] CVN impact testing to be P-plate frequency testing in accordance with ASTM A673. Code Charpy test pieces with respect to heat/plate number and record such code on mill-test report of steel supplier with test result. If directed, package broken pieces from each test (three specimens, six halves) and forward to the quality-assurance organization of the jurisdictional authority. Use average of three tests. If energy value for more than one of three specimens is below minimum average requirements or if energy value for one of three specimens is less than 2/3 of specified minimum requirements, retest and obtain energy value from each of three retest specimens equal to or exceeding specified minimum average requirement.

[*b] Zone 1: Minimum service temperature zero degree F (minus 17.8C) and above.

*c Zone 2: Minimum service temperature from minus 1F to minus 30F (minus 28.3C to minus 34.4C).

*d Zone 3: Minimum service temperature from minus 31F to minus 60F (minus 35C to minus 51.1C).

*e If the yield strength of the material exceeds 65 ksi (448.159MPa), reduce temperature for CVN value for acceptability by 15F (8.3C) for each increment of 10 ksi (68.947MPa) above 65 ksi (448.159MPa). Yield strength is value given in certified mill-test report.

*f ASTM A517 Charpy requirements are the same as for ASTM A514.

END OF SECTION

SECTION 05500

MISCELLANEOUS METAL

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing miscellaneous metal, with the exception of ornamental (architectural) metal and metalwork provided as a part of mechanical, electrical and construction systems.

B. Related Work Specified Elsewhere:
1. Concrete, concrete fill and nonshrink grout: Section 03300.
2. Structural steel: Section 05120.
3. Handrails and Railings: Section 05521.
4. Gratings and Floor Plates: Section 05531.
5. Field painting: Section 09920.
6. Concrete formwork: Section 03100.
7. Concrete reinforcement: Section 03200.
8. Wire Mesh Partitions: Section 10605

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings: Detail fabrication and erection of each metal fabrication indicated.

1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
2. Manufacturer's standard drawings may be submitted in lieu of Contractor-prepared shop drawings if manufacturer's standard drawings show required details.

B. Certification:
1. Certification that welding personnel are currently qualified in accordance with AWS D1.1.
2. Mill Certificates: Signed by manufacturers of stainless-steel sheet certifying that products furnished comply with requirements for corrosion resistance of Type 316 stainless steel.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: D1.1.
3. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design and Plastic Design (Do not use plastic design).
4. SSPC: SP 11, Paint 12.
5. FED STD: 595.
6. MS: MIL-P-21035.
7. FS: A-A-462, FF-B-588, FF-H-116, FF-P-395, FF-S-325, RR-T-650, TT-P-86.

8. ASTM: A36, A53, A74, A108, A123, A167, A193, A229, A242, A276, A307, A313, A325, A413,A490, A501, A536, A570, A572, A588, A666, A780, A786/A786M, B 221, B 632, B633, D412, D1187, E488, F 593, F 594, F1554.
9. AGA: The Design and Fabrication of Galvanized Products.
10. ANSI: A14.3
11. ASME: A 17.1, B18.6.3, B18.21.1, B18.22.1.

B. Qualifications of Welding Personnel:
1. Welding: Qualify procedures and personnel according to the following:
a. AWS D1.1, "Structural Welding Code--Steel."
b. AWS D1.2, "Structural Welding Code--Aluminum."
c. AWS D1.3, "Structural Welding Code--Sheet Steel."
d. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.

C. Fabricator Qualifications: A firm experienced in producing metal fabrications similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

D. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.04 PROJECT CONDITIONS:

A. Field Measurements: Where metal fabrications are indicated to fit walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products undamaged.

B. Store products so as to prevent rust.

C. Handle products so as to prevent damage.

D. After completion of factory testing, package and ship hatches as directed.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. General Requirements:
   1. Insofar as practicable, furnish similar products of a single manufacturer.
   2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.02 FERROUS METALS:

A. Structural steel: Plates, shapes, bars and angles, ASTM A36.

B. Rolled-Steel Floor plate: ASTM A786/A786M; Fabricate raised-pattern floor plates from rolled-steel floor plate, galvanized after fabrication, of thickness and in pattern indicated below:
   1. Thickness: Minimum 1/4 inch, unless otherwise shown or calculated.
   2. Pattern: No. 2, or as selected from manufacturer's standard patterns; flat back.

C. High-strength low-alloy structural steel:
   1. ASTM A242.
   2. Resistance to atmospheric corrosion: Four times that of carbon steel, minimum.

D. Load-carrier beams: ASTM A588.

E. Structural tubing: ASTM A501.

F. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.

G. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.

H. Stainless-Steel Bars and Shapes: ASTM A276, Type 304. Type 316L for corrosive environments.

I. Hot-rolled carbon steel sheets and strips: ASTM A570.

J. Pipe, Pipe Sleeves and Pipe Fittings:
   1. Cast iron: ASTM A74, service weight.
   2. Steel: ASTM A53, galvanized unless otherwise shown or specified.

K. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless-steel eyes, spring-loaded catches and mounting components.

2.03 ALUMINUM:

A. Aluminum Extrusions: ASTM B221, Alloy 6063

B. Aluminum-Alloy Rolled Tread Plate: ASTM B632/B 632M, Alloy 6061.

C. Cast Aluminum.

2.04 COATINGS:

A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.

B. Zinc-rich paint: MS MIL-P-21035.

C. Electrodeposited zinc coating: ASTM B63

D. Galvanizing repair compound: Stick form, melting point 600F to 650F, GALVABAR or equal.

E. Bituminous coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.05 FASTENERS:

A. General: Provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.

B. Screws: Material, type and size to suit the purpose; steel, except stainless, cadmium-plated.
   1. Stainless steel, ASTM A193, Alloy S30400.

C. Machine bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
   1. Carbon steel: ASTM A307, Grade B, galvanized.
   2. Stainless steel: ASTM A193, Class 1A.

D. Toggle bolt: FS FF-B-588.

E. Drive stud: FS FF-S-325, Group 6.

F. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.

G. Screw anchors: Lead or plastic for wood or metal screws.

H. Anchor-bolt sleeve: Corrugated high-density polyethylene plastic.

I. Powder actuated: FS FF-P-395.

J. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
   1. Material: Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

K. Internally Threaded Steel Anchor: ASTM A108.

2.06 CONCRETE AND GROUT:

A. Nonshrink Grout: Section 03300.

B. Concrete Fill: Normal weight, minimum 3,000 psi structural concrete as required in Section 03300, except limit the max. coarse aggregate size to #8.
   1. Non-slip aggregate: Fused aluminum oxide grits or crushed emery, factory graded and packaged, rust-proof, non glazing and unaffected by moisture and cleaning materials.
   2. Surface hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

2.07 FABRICATION, GENERAL:

A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Shear and punch metals cleanly and accurately. Remove burrs.

C. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Weld corners and seams continuously to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

E. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

F. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

G. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.

H. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
   1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

I. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges

J. Remove sharp or rough areas on exposed traffic surfaces.

K. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

2.08 LADDERS:

A. General: Fabricate ladders for locations shown, with dimensions, spacings, details, and anchorages as indicated.
   1. Comply with ANSI A14.3, unless otherwise indicated.
   2. For elevator pit ladders, comply with ASME A17.1.

B. Siderails: Continuous, 1/2-by-2-1/2-inch steel flat bars, with eased edges.

C. Bar Rungs: 3/4-inch diameter steel bars, spaced 12 inches o.c., unless shown otherwise.

D. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.

E. Support each ladder at top and bottom and not more than 48 inches o.c. with welded or bolted steel brackets. Size brackets to support design loads specified in ANSI A14.3.

F. Provide nonslip surfaces on top of each rung by coating with abrasive material metallically bonded to rung by a proprietary process.

G. Galvanize ladders, including brackets and fasteners, in exterior locations and in areas with corrosive environments:

2.09 LADDER SAFETY CAGES:

A. General: Fabricate ladder safety cages to comply with ANSI A14.3. Assemble by welding or riveting.

B. Primary Hoops: 5/16-by-4-inch steel flat bar hoops. Provide at tops and bottoms of cages and spaced not more than 20 feet o.c.

C. Secondary Intermediate Hoops: 5/16-by-2-inch steel flat bar hoops, spaced not more than 48 inches o.c. between primary hoops.

D. Vertical Bars: 5/16-by-2-inch steel flat bars secured to each hoop, spaced approximately 9 inches o.c.

E. Fasten assembled safety cage to ladder rails and adjacent construction by welding or riveting, unless otherwise indicated.

F. Galvanize ladder safety cages, including fasteners, in exterior locations and in areas with corrosive environments.

2.10 SHIP'S LADDERS:

A. General: Design in accordance with AISC Specification for Structural Steel for Buildings-Allowable Stress Design, NAAMM Metal Stairs Manual and applicable OSHA requirements.
   1. Minimum live load for stairs: 100 psf.
   2. Stringers: At platforms and landings, extend stringers around perimeters. Close ends with continuously welded closure plates, ground smooth and flush.

B. Provide ship's ladders where shown or indicated. Fabricate of open-type construction with structural-steel channel or steel plate stringers, steel pipe handrails, and steel bar grating treads, unless otherwise indicated. Provide brackets and fittings for installation.

C. Treads, platforms and landings fabricated of steel plate with nonslip surface or steel grating, as shown.

D. As far as practicable, holes for rivets, bolts and screws located in concealed positions.

E. Galvanize ship's ladder, including fasteners, in exterior locations and in areas with corrosive environments.

F. Comply with applicable requirements in Section 05520 for steel pipe railings.

2.11 SAFETY TREAD:

A. FS RR-T-650, Type C, metallic, nonskid, class and style as shown.

B. Drilled and countersunk to receive flathead screws.

2.12 STEEL LINTELS:

A. Fabricated of structural steel.

B. Multiple members riveted or welded back-to-back or separated by spacers.

C. Shop-painted, except hot-dip galvanized after fabrication where used in exterior walls.

2.12 SHELF ANGLES:

A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than 6 inches from ends and 24 inches o.c., unless otherwise indicated.

B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete. Align expansion joints in angles with indicated control and expansion joints in cavity-wall exterior wythe.

C. Galvanize shelf angles to be installed in exterior walls.

D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.13 CORNER GUARD, CURB ANGLE AND BUMPER:

A. Fabricated of structural steel.

B. Shop-painted.

2.14 UNDERGROUND SAFETY WALK:

A. Locking pin: Stainless steel, diameter to fit receptacle in hinge assembly with tolerance not greater than plus-or-minus 1/64 inch.

B. Locking-pin chain: Fabricated of 0.128-inch diameter steel spring wire.

C. Plug-welded in accordance with AWS D1.1.

D. Stainless steel: ASTM A276, Alloy S20200.

E. Bolts and washers: ASTM A325 or ASTM A490, nonrising and vibration-proof.

F. Spring wire: ASTM A229, Class 1 or 4.

G. Ferrous-metal components galvanized after fabrication.

H. Gratings and Floor Plates: Section 05531.

2.15 AERIAL SAFETY WALK:

A. Fabricated of floor plate, diamond pattern, flatback.

B. Abrasive surface on plates, unless otherwise shown.

C. Structural-steel angle frames anchored to supporting structure.

D. Plates in sections of convenient lengths for handling and with finger holes for lifting.

E. Galvanized after fabrication.

F. Bolts: Stainless steel.

2.16 SCREEN AT PLATFORM BENCH:

A. Materials:
   1. Base: Steel, welded.
   2. Bar frame: Steel, welded.
   3. Screen:
      a. Wire cloth: 0.080-inch diameter steel-wire mesh, galvanized after weaving.
      b. Frame: Steel, drilled for fasteners, holes punched for wire mesh and corners welded, galvanized.

B. Fabrication: Insert wire cloth with wires parallel to frame members, with ends of wires through holes in frame and welded to inner surface of channel.

C. Finish: Field-painted in accordance with Section 09920; FED STD 595, Color No. 20040.

2.17 CAST NOSING:

A. Cast aluminum: Cross-hatched units, 4 inches wide with 1-inch lip, for casting into concrete steps

B. Apply bituminous paint to concealed bottoms, sides, and edges of units set into concrete.

2.18 PEDESTRIAN BARRIER:

A. Tubing: Hot-formed square steel. Fabricated as follows:
   1. Heated and bent smoothly without distortion
   2. Joints fully welded as shown.
   3. Intersections coped, fully welded and ground smooth and flush.

B. Plate: Structural steel.

C. Floor-cover flange: Cast steel, as shown.

D. Finish: Shop-coated and finish painted in accordance with Section 09920.

2.19 BOLLARDS:

A. Pipe: Black Steel, ASTM A53, Type E, Grade A, Schedule 80, sized as shown, with 1/4-inch steel-plate cap welded all around and weld ground smooth

B. Eyebolt: 1/4-inch diameter steel rod with 1/2-inch diameter eye.

C. Concrete fill: Section 03300, Class 3000.

D. Coating:
1. Shop paint.
2. Finish paint: Aliphatic system as specified in Section 09920.
3. Hot-dip galvanize exterior bollards in accordance with ASTM A123 before bonderizing and shop priming.

E. Chain: Guard chain, galvanized and painted to match bollard.

2.20 PARKING METER POSTS:

A. Pipe: Black steel, ASTM A53, Type E, Grade A, Schedule 40, two-inch nominal OD.

B. Hot-dip galvanize after cutting to length.

C. See Sections 03100, 03200, and 03300 for concrete footing.

2.21 MISCELLANEOUS ITEMS:

A. Fabricate metal items indicated on the drawings from materials shown or, if not otherwise described, from steel or from galvanized steel wherever exposed to the weather or in contact with concrete or masonry.

B. Make miscellaneous items to the size and configuration indicated, welded or bolted at joints to develop full strength equal to a continuous member, and in every way complete for the intended purpose and finished in appearance.

C. Pylon-Base Ring: Structural steel, galvanized after fabrication.

D. Lifting Eye: ASTM A572, Grade 50, one-inch diameter steel rod, welded, galvanized after fabrication.

2.22 FINISHES:

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish metal fabrications after assembly.

B. Galvanizing:
1. Clean ferrous metal thoroughly before applying zinc coating.
2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than 2.0 ounces per square foot.

C. Shop Paint:
   1. Ferrous metal thoroughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
   2. Zinc yellow iron-oxide primer or red-lead base primer applied so as to thoroughly cover surfaces without leaving runs or sags.

D. Stainless Steel: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

E. Aluminum: AA-M10 (Mechanical Finish: as fabricated, unspecified).

F. Non-Slip Abrasive Surfaces: SLIP-NOT as manufactured by the W. S. Molnar Company or approved equal. Fabricate from steel plate or bar with abrasive material metallically bonded to steel by a proprietary process. Provide material with coefficient of friction of 0.6 or higher when tested according to ASTM C1028.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Remove foreign substances from surfaces to receive metal items.

B. Protect surrounding surfaces from damage while performing the work of this section.

3.02 INSTALLATION, GENERAL:

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

E. Field Welding: Comply with the following requirements:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.03 INSTALLING NOSINGS:

A. Center nosings on tread widths.

B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

3.04 INSTALLING BOLLARDS:

A. Anchor bollards in concrete with pipe sleeves preset and anchored into concrete. After bollards have been inserted into sleeves, fill annular space between bollard and sleeve solidly with nonshrink, nonmetallic grout, mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/4 inch toward bollard.

3.05 PAINTING AND REPAIRING COATED SURFACES:

A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finished work, except items encased in concrete.

B. Where shop coat is abraded or burned by welding, clean and touch-up.

C. Touch-up primed surfaces with same material as coating.

D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.

E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
1. Wire-brush areas to be coated to bright metal.
2. Apply galvanizing repair compound at rate of two ounces per square foot.

END OF SECTION

SECTION 05581

FORMED METAL FABRICATIONS - STATION KIOSKS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the fabrication and installation of steel cladding and insulated panels for station kiosks.

B. Related Work Specified Elsewhere:

C. Cast-in-Place Structural Concrete: Section 03300.

D. Structural Steel: Section 05120.

E. Structural Steel Metal Decking: Section 05310.

F. Seals and Sealants: Section 07900.

G. Finish Hardware: Section 08710.

H. Glass and Glazing: Section 08800.

I. Metal Doors and Frames: Section 08810.

J. Acoustical Snap-In Metal Pan Ceilings: Section 09520.

K. Field Painting: Section 09920.

L. Kiosk Mechanical Work: Section 15736.

M. Grounding and Bonding: Section 16060.

N. Wire and Cable: Section 16120.

O. Wire Connection Accessories: Section 16125

P. Raceways, Boxes and Cabinets: Section 16130.

Q. Wiring and Control Devices: Section 16145.

R. Circuit Breakers, Panelboards and Load Centers: Section 16440.

S. Lighting Fixtures: Section 16525

T. Kiosks Systems: Section 16733.

1.02 SUBMITTALS:

Submit the following samples for approval in accordance with the Special Conditions and with the additional requirements as specified for each:

A. Shop Drawings:
   1. Details of construction and installation of fabricated items including materials, dimensions, methods of joining, welding, fastening and anchoring.
   2. Obtain approval for minor variations in detail for the purpose of improving fabrication and installation procedures, but not affecting general design for structural stability.

B. Samples: Three of each of the following in each finish to be used in the work:
   1. Sheet metal: Four inches square.
   2. Tubing and extension: Six inch lengths.
   3. Insulated panels: Six inches square. Fabricate to show typical metal panel with fasteners on two edges, opened to expose core material on two edges. Furnish with required finish material on one face and unfinished on other face.

1.03 QUALITY ASSURANCE:

A. Reference Codes and Specifications:
   1. Codes and regulations of the jurisdictional authorities.
   2. ASTM: A36, A501, A526, B221, C272, C518, D696, D1621, E84, E96.
   3. FED STD: 595A.
   4. AWS: D1.1.
   5. MS: MIL-P-21035
   6. SSPC: SP-2, SP-3, SP-10

B. Qualification of Welders:
   1. Employ operators, who have been qualified previously by the test as described by the American Welding Society's Standard D1.1, to perform welding.
   2. Furnish certificates that each operator has passed the tests.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products in good conditions

B. Store products so as to prevent corrosion, deterioration, and damage.

C. Handle products so as to prevent damage.

D. Deliver fabricated insulated panels to the site individually wrapped and packed to avoid damage. Protect from water, dirt, and other potentially harmful substances.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. General: Insofar as practicable, furnish products of a single manufacturer.

B. Steel Sheet (Steel Cladding): ASTM A526, coating G235, thickness of sheet as shown.

C. Steel Rods, Bars, and Shapes: ASTM A36.

D. Aluminum Bars: ASTM B221, alloy 6063-T52.

E. Screws: Corrosion resistant, finished to match adjacent material.

F. Pop Rivets: Stainless steel with mandrel head, series 4.

G. Rigid Insulation: Extruded polystyrene rigid foam, Styrofoam HI-115 by DOW Chemical Company, or approved equal, with the following additional requirements:

Flame Spread	ASTM E84	Less than 25.
Compressive strength	ASTM D1621	115-psi minimum at five percent deflection.
Water absorption	ASTM C272	1.0 percent maximum.
Water vapor transmission	ASTM E96	1.0 perm maximum for one-inch thickness
Linear coefficient of thermal expansion	ASTM D696	3.5 times 10^{-5} inches per degree Fahrenheit in a range of minus 260°F to plus 70°F.
Thermal conductivity at 40°F mean	ASTM C518	0.185 BTU/hr/ft^2/degree F/inch, maximum.

H. Adhesive: Rubber-based, solvent-dispersed type, compatible with the insulation and meeting AFG-01 and HUDFHA UM60 Standards.

I. Polyurethane Finish: Polane System by Sherwin-Williams, or approved equal.
   1. Shop primer: Rust-inhibitive vinyl epoxy, Wash Primer Green, P60.
   2. Intermediate high-build coat: Title Clad II Primer, B62.
   3. Finish color coat: Polane, semi-gloss sheen, FED STD 595A Color No. 20040.
   4. Spatter surface texture: Polane T, semi-gloss sheen, Spatter Surface Texture, FED STD 595A, Color No. 20040.

J. Lifting Hardware: Stanley No. 1215, No. 2, or approved equal, minimum 3-1/2 inches by 3-3/4 inches with 2-1/4 inch outside diameter of lifting ring, 19/32-inch overall depth. Thickness of steel minimum 0.083 inches, zinc-plated finish.

K. Miscellaneous fasteners, clips, and angles: Type and size as shown, galvanized and finished to match adjacent material.

L. Galvanizing Repair Compound: Zinc-dust zinc-oxide primer conforming to MS MIL-P-21035.

M. Bituminous Paint, Preformed Tape: Material as approved.

2.02 FABRICATION, GENERAL:

A. Do not start work prior to approval of shop drawings.

B. Verify dimensions before proceeding with work. Obtain measurements at structure.

C. Match mark shop-prepared work to ensure proper assembly and fit in the field.

D. Match exposed work to produce continuity of line and design. Accurately fit and rigidly secure joints in exposed work with hairline contacts. Wherever possible, position holes for fasteners in concealed areas.

E. Coat welds and repair damage to zinc-coated surfaces as follows:

F. Wire brush areas to be coated to bright metal.

G. Apply galvanizing repair compound at a rate equal to two ounces of zinc per square foot. Feather edges of the application.

H. Use only material free from mill scale, flake rust and mill pitting.

I. form and finish items to shape and size with sharp angles and lines. Provide cut-outs to sizes and in locations required.

J. Countersink metalwork to receive the required hardware, and provide proper bevels and clearances.

K. Weld plates on for mounting hardware. Drill or punch holes for bolts and screws. Conceal fastenings wherever practicable.

L. Grind exposed edges of work smooth. Construct joints exposed to weather to exclude water.

M. Provide brackets, lugs, and similar accessories, required for installation, as part of the metal item.

N. Fasteners, Anchors, and Inserts: Use sizes and types shown on approved shop drawings.
O. Bituminous Paint, Preformed Tape: Material as approved.

2.03 FABRICATION, INSULATED PANELS:

A. Steel sheet: Brake-form or die-form as required, free from oil-canning, bends, warps, and other defects. Drill or punch as required for assembly and installation. Continuously weld corners and connections, and grind smooth and flush.

B. Rigid insulation core: One layer for total thickness required. Cut to size and shape to fit over core of panels to thickness shown, tight around perimeter.

C. Assembly: Apply adhesive to steel sheet faces according to manufacturer's recommendation. Provide full adhesive contact between core and face sheets for wall and roof panels. Provide full adhesive contact between core and lower face sheet at floor panels.

D. Glazing members: Screw aluminum bar sections to insulated panels as shown.

E. Install pass-through with door or inside and trim secured on exterior as shown.

F. Install lifting hardware with sheet metal screws, one at each corner of hardware plate.

2.03 FABRICATION, STEEL CLADDING:

A. Form as shown, free from oil-canning, bends, warps and other defects.

B. Drill or punch for attachment to structural members so that fasteners will not be visible after installation of monitoring cabinets.

2.04 FINISH, GENERAL:

A. Prepare surface for priming as follows:

B. Clean bare steel surfaces according to SSPC SP-10 (Near-White Metal Blast Cleaning).

C. Clean galvanized steel surfaces according to SSPC SP-2 (Hand Tool Cleaning) or SP-3 (Power Tool Cleaning) and the recommendation of the paint manufacturer, so as to remove white rust (zinc oxide) but not to remove the galvanizing.

D. Coat welds and repair damage to zinc-coated surfaces as follows:
1. Wire brush areas to be coated to bright metal.
2. Apply galvanizing repair compound at a rate equal to two ounces of zinc per square foot. Feather edges of the application.

E. Apply minimum coating as follows to all metals:
1. First coat, primer: 0.3 mils DFT.
2. Second coat, intermediate high-build coating: 4.0 mils DFT.
3. Third coat, finish color coat: 2 mils DFT in brown color, FED STD 595A Color No. 20040. Omit on totally concealed surfaces only.
4. Fourth coat, spatter surface texture: Texture matching approved sample, in brown color, FED STD 595A Color No. 20040. Omit on totally concealed surfaces only.

F. Apply finish on exposed areas and edges of each insulated panel.

G. Separate dissimilar metals at surfaces of contact with one coat of alkali-resistant bituminous paint or other protective coating to prevent galvanic action.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL:

A. Provide anchors and inserts in sufficient number for proper fastening of metal items.

B. Set metalwork accurately, level, plumb, and in true alignment with adjoining work.

C. Drill holes as required for bolts and screws in supports, steel cladding and in insulated panels when in different locations from hole prepared in shop fabrication. Conceal fasteners where possible. Where exposed fasteners are necessary, match fasteners to adjacent metals.

D. Use fastenings and anchors of size and type as shown on approved shop drawings. Conceal fasteners wherever practicable.

E. Provide sealant material as required to seal panels against moisture infiltration, in accordance with Section 07900.

F. Coordinate installation of ornamental metal work with work of other trades.

G. Provide protection against galvanic action between dissimilar metals by completely covering contact surfaces with heavy brush coat of bituminous paint or by separating contact surfaces with preformed tape.

H. Protect exposed metal work throughout work to prevent scratches, stains, discoloration and other damage.

I. Set metal items level, plumb, and in true alignment with adjoining work. Set built-up parts true to line and without sharp bends, twists or kinks.

J. Fasten metal work in place so that items will not be distorted, finish will not be impaired, nor fasteners overstressed from expansion and contraction of metal.

3.02 INSTALLATION, STEEL CLADDING:

A. Apply to structural members by securing in position with sheet metal screws or pop rivets, fastener selections as best suited for purpose intended to provide secure anchorage and stability of cladding material. Locate fasteners at points not visible from the interior or exterior of the kiosk after installation of cabinets.

3.03 CLEAN-UP:

A. Upon completion of installation, clean surfaces of metalwork by procedures recommended by metalwork manufacturer.

B. Clean-up rubbish and debris caused by this work and remove from the site

C. Leave areas surrounding the work in broom-clean condition.

3.04 PAINTING AND REPAIR OF SURFACES:

A. Where finish coat is damaged during shipment or installation, field touch-up damaged areas with air-dry paint of type to fuse with finish material as recommended by manufacturer of finish material/

3.05 ACCEPTANCE TEST/INSPECTION:

A. The table below shall be utilize to preform the acceptance test/inspection for the kiosk construction.

ITEM	PASS	FAIL
Compliance with all requirements in Section 4 and Kiosk Enclosure Fabrication Contract drawings.		
Check for proper structural fit and finish (no sharp metal edges, proper fit at corners etc.)		
Check for proper operation of door and door lock		
Check for proper fit of glass		
Check paint for nicks, scratches and proper application.		
Test and measure to ensure proper voltages (AC) is ± 5% of specified voltage.		
Test AC circuit breakers proper operation.		
Test all lights.		
Test all air conditioning controls and calibrate temperature setting with a thermometer and provide calibration chart.		
Test all heater controls for proper operation.		

END OF SECTION

SECTION 05700

ORNAMENTAL METAL

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing ornamental (architectural) metalwork.

B. Related Work Specified Elsewhere:
   1. Not used.
   2. Hydraulic elevator: Section 14200.

1.02 PERFORMANCE REQUIREMENTS FOR HANDRAILS AND RAILINGS:

A. Structural Performance of Handrails and Railings: Provide handrails and railings complying with requirements of ASTM E 985 for structural performance, based on testing performed according to ASTM E 894 and ASTM E 935.

B. Thermal Movements: Provide handrails and railings that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
   1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

   1. Shop Drawings: Show fabrication and installation of ornamental metal. Include plans, elevations, component details, and attachments to other Work. Indicate materials and profiles of each ornamental metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.
      a. Include setting drawings, templates, and directions for installing anchor bolts and other anchorages.
      b. Obtain approval for minor variations in detail for the purpose of improving fabrication and installation procedures, but not affecting general design for structural stability.

   2. Samples for Verification: Three of each of the following in each finish to be used in the work. For each profile and pattern of fabricated metal and for each type of metal finish required, prepared on metal of same thickness and alloy indicated for the Work.
      a. Include 6-inch long samples of linear shapes, tubing and extrusions
      b. Include 4-inch square samples of plates and sheet metal.
      c. Welded joints: For color matching.
      d. Brazed joints: Typical for work involved.

   3. Certification:
      a. Welding Certificates: Copies of certificates for welding procedures and

personnel.

b. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

c. Certified test reports: Certified test reports verifying that epoxy grout conforms to specified requirements.

d. Certification that adhesive is appropriate for the long-term intended use.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: A5.7, A5.8, D1.1, D1.3.
3. PEI: S-100.
4. MS: MIL-C-18480.
5. ASTM: A36, A48, A153, A276, A312, A366, A413, A424, A500, A501, A536, A554, A653, A666, A743, B43, B135, B455, B584, C307, C413, C552, C579, C580, D1187, D3656, E527.
6. ANSI: A156.18.
7. FS TT-P-664.
8. SSPS-Paint 5, Paint 12.
9. NAAMM.

B. Installer Qualifications: Arrange for installation of ornamental metal specified in this Section by the same firm that fabricated it.

C. Fabricator Qualifications: A firm experienced in producing ornamental metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

D. Welding Standards: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.3, "Structural Welding Code--Sheet Steel."

1.05 DELIVERY, STORAGE, AND HANDLING:

A. Store ornamental metal inside a well-ventilated area, away from uncured concrete and masonry, and protected from weather, moisture, soiling, abrasion, extreme temperatures, and humidity.

B. Deliver and store cast-metal products in wooden crates surrounded by sufficient excelsior to ensure that products will not be cracked or otherwise damaged.

1.06 PROJECT CONDITIONS:

A. Field Measurements: Where ornamental metal is indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating ornamental metal without field measurements. Coordinate other construction to ensure that actual dimensions correspond to established dimensions.

1.07 COORDINATION

A. Coordinate installation of anchorages for ornamental metal items. Furnish Setting Drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL:

A. Insofar as practicable, furnish products of a single manufacturer.

2.02 METALS:

A. General: Provide metals free from surface blemishes where exposed to view in finished unit. Exposed-to-view surfaces exhibiting pitting, seam marks, roller marks, stains, discolorations, or other imperfections on finished units are not acceptable.

B. Bronze: Provide copper alloy of type and form indicated to comply with the following requirements:
1. Extruded Shapes: ASTM B455, Alloy UNS No. C38500 (extruded architectural bronze).
2. Plate, Sheet, Strip, and Bars: ASTM B36, Alloy UNS No. C28000 (muntz metal, 60 percent copper).
3. Seamless Pipe: ASTM B43, Alloy UNS No. C23000.
4. Seamless Tubes: ASTM B135, Alloy UNS No. C23000 (red brass, 85 percent copper).
5. Delete subparagraph above or below. Verify availability and color match with other copper-alloy forms. See Evaluations.
6. Sand Castings: ASTM B584, Alloy UNS No. C86500 (No. 1 manganese bronze).
7. Stainless Steel: Grade and type designated below for each form required:
8. Pipe: ASTM A312, Grade TP 304.
9. Castings: ASTM A743, Grade CF 8 or Grade CF 20.
10. Sheet, Strip, Plate, and Flat Bar: ASTM A666, Type 304.
11. Bars and Shapes: ASTM A276, Type 304.Select subparagraph above or below.

C. Steel: Provide steel in form indicated to comply with the following requirements:
1. Tubing: Cold formed, ASTM A500.
2. Steel Plate, Shapes, and Bars: ASTM A36.
3. Steel Sheet:
   a. Commercial-quality, cold-rolled, stretcher-leveled, carbon-steel sheet complying with ASTM A 366, Class I, matte finish.
   b. ASTM A653, mild-annealed, leveled, cold-rolled, galvanized, 16-gauge.

D. Base Metal for Porcelain Enamel: ASTM A424, vitreous enameling steel of low metalloid and copper content, manufactured and processed for the production of architectural porcelain enamel units, 16-gauge.

E. Porcelain Enamel Panel Liners: ASTM A653, hot dipped galvanized steel sheet, G90 zinc coating, 20-gauge.

2.03 MISCELLANEOUS MATERIALS:

A. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes as

recommended by producer of metal to be welded, complying with applicable AWS specifications, and as required for color match, strength, and compatibility in fabricated items.

B. Fasteners: Use fasteners of same basic metal as fastened metal, unless otherwise indicated. Do not use metals that are corrosive or incompatible with materials joined.
1. Provide concealed fasteners for interconnecting ornamental metal components and for attaching them to other work, unless otherwise indicated.
2. Provide concealed fasteners for interconnecting ornamental metal components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method.
3. Provide Phillips flat-head machine screws for exposed fasteners, unless otherwise indicated.

C. Cast-in-Place and Postinstalled Anchors: Anchors of type indicated below, fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
1. Cast-in-place anchors
2. Chemical anchors.
3. Expansion anchors.

D. Insect Screen: ASTM D3656, with aluminum or galvanized steel frame as shown.

E. Epoxy Grout: Nonshrink, nonstaining, 100-percent solids, two-component or three-component epoxy-resin system, that has been in successful use for an equivalent application for a minimum of five years.
1. On horizontal applications: Self-leveling type.
2. On vertical and overhead surface application: Non-sag type.
3. Physical properties:

Property	Requirement	ASTM Test Method
Tensile strength	1,800-psi minimum in seven days	C307
Compressive strength	13,500-psi minimum in 28 days	C579
Modulus of rupture	13,500 psi	C580
Water absorption	One-percent maximum, two hours at 212F	C413

F. Panel Core: Cellular glass, ASTM C552, Type IV, one-inch thick.

G. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements of FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.

H. Shop Primer for Galvanized Steel: Zinc-dust, zinc-oxide primer formulated for priming zinc-coated steel and for compatibility with finish paint systems indicated, and complying with SSPC-Paint 5.

I. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187

J. Adhesive: Hot spray contact cement, certified by fabricator as appropriate for the long-term intended use

2.04 FABRICATION, GENERAL:

A. Form ornamental metal to required shapes and sizes, with true curves, lines, and angles. Provide components in sizes and profiles indicated, but not less than that needed to comply with requirements indicated for structural performance.

B. Provide necessary rebates, lugs, and brackets to assemble units and to attach to other work. Drill and tap for required fasteners, unless otherwise indicated. Use concealed fasteners where possible.

C. Comply with AWS for recommended practices in shop welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed joints of all flux, and dress all exposed and contact surfaces.
1. Type, size and spacing of welds: As shown on approved shop drawings.
2. Remove weld spatter and welding oxides from finished surfaces by descaling and grinding.
3. Use oxyacetylene method for welding joints of extruded architectural bronze, 16-B&S gauge or heavier.
4. To ensure color match at exposed joints, insert pieces of the base metal or low-fuming bronze, conforming to AWS A5.7, Classification R Cu Zn C as filler material. Adjust oxidizing flame to minimize porosity of joint.
5. Grind and polish welded beads on exposed polished surfaces to match and blend with finish on adjacent parent metal.

D. Mill joints to a tight, hairline fit. Cope or miter corner joints. Form joints exposed to weather to exclude water penetration.

E. Provide castings that are sound and free of warp, cracks, blowholes, or other defects that impair strength or appearance. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks.

F. Finish exposed surfaces to smooth, sharp, well-defined lines and arris.

G. Assemble items in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

H. Cleaning metal surfaces:
1. After grinding and polishing or where subject to severe forming operations, remove extraneous material from metal surfaces, thoroughly rinse with clear water and dry.
2. Remove lubricants used in fabrication before work leaves shop.
3. Match-mark materials for field assembly as necessary. Arrange sequence of shipments to expedite erection and to minimize field handling of material.

2.05 FABRICATING HANDRAILS AND RAILINGS:

A. Nonwelded Connections: Fabricate handrails and railings to interconnect members with concealed mechanical fasteners and fittings, unless otherwise indicated. Fabricate members

and fittings to produce flush, smooth, rigid, hairline joints.

1. Fabricate splice joints for field connection using an epoxy structural adhesive where this is fabricator's standard splicing method.

B. Welded Connections: Fabricate handrails and railings for connecting members by welding. Cope components at perpendicular and skew connections to provide close fit, or use fittings designed for this purpose. Weld connections continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove flux immediately.
4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces
5. Provide welded connections for stainless-steel handrails and railings.
6. Provide welded connections for ferrous handrails and railings.

C. Retain paragraph and subparagraphs below if required for brazing copper-alloy railings. See Evaluations.Brazed Connections: Fabricate bronze handrails and railings for connecting members by brazing. For connections made during fabrication, braze corners and seams continuously to comply with the following:

1. Use materials and methods that match color of base metal, minimize distortion, and develop maximum strength and corrosion resistance.
2. Remove flux immediately.
3. Where exposed field connections are necessary, insert inside sleeves and secure at bottom with flush screws to provide hairline joint. Finish exposed surfaces smooth and blended so no roughness shows after finishing and brazed surface matches contours of adjoining surfaces.

D. Form changes in direction of railing members as follows shown on approved shop drawings.Retain one of seven subparagraphs below; if retaining more than one, also retain last subparagraph. If there is a need to limit specific methods to selected locations or to railings of different metals, select method that predominates as default by adding phrase ", unless otherwise indicated," and qualify other methods retained by adding phrase "where indicated."

E. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain profile of member throughout entire bend without buckling, twisting, or otherwise deforming exposed surfaces of handrail and railing components

F. For handrails and railings with nonwelded connections that are exposed to exterior or to moisture from condensation or other sources, provide weep holes or another means to drain water entrapped in hollow sections of railing members.

G. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated; close ends of returns.

H. Close exposed ends of handrail and railing members with manufacturer's standard prefabricated end fittings.

I. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect handrail and railing members to other work, unless otherwise indicated.

1. Furnish inserts and other anchorage devices for connecting handrails and railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by handrails and railings. Coordinate anchorage devices with

supporting structure.

2. For railing posts set in concrete, provide preset sleeves of steel, not less than 6 inches long and inside dimensions not less than 1/2 inch greater than outside dimensions of post, with steel plate forming bottom closure.

2.06 FABRICATING BRONZE CLADDING:

A. Brake-formed as shown on approved shop drawings. Laminate to backup material to achieve permanent bond and as recommended by bronze manufacturer.

B. Fit and braze exposed joints in cladding with copper-phosphorous alloy or silver alloy, conforming to AWS A5.8, Classification B Cu P-5 and B Ag 1, respectively. Clean joints and apply flux properly before brazing. After brazing, remove excess brazing metal from face of work.

2.07 FABRICATING STEEL CLADDING:

A. Formed of steel sheet ASTM 366, with baked-enamel finish.

B. Weld and fill seams and joints before finishing.

2.08 INSULATED PANELS FOR ELEVATOR HOISTWAYS:

A. Consisting of exposed face of bronze or stainless steel sheet, back face of steel sheet, panel core and adhesive.

B. Fabricated as specified for bronze or stainless steel cladding.

2.09 PORCELAIN ENAMEL PANELS:

A. Laminated type in sizes and shapes shown conforming with PEI standards specified.

2.10 FINISHES, GENERAL:

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.11 BRONZE FINISHES:

A. Base-metal finish: Medium satin wheel-polished or belt-polished with aluminum oxide or silicon carbide abrasives of 80-120 grit, using a peripheral wheel speed of 6,000 fpm to a smooth dull finish with a directional pattern.

B. Applied finish: ANSI A156.18 finish number 613, dark oxidized satin bronze, oil rubbed; oxide or sulfide chemical process using immersion or brushed on application as recommended by the manufacturer.

1. Color of finish: Match sample on file with the Authority's Representative.

2.12 STAINLESS-STEEL FINISHES:

A. Remove or blend tool and die marks and stretch lines into finish.

B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

C. Satin, Directional Polish: ANSI A156.18 finish number 654, satin stainless steel.

D. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.13 STEEL FINISHES:

A. Galvanizing: Hot-dip galvanize products made from rolled, pressed, and forged steel shapes, castings, plates, bars, and strips indicated to be galvanized to comply with ASTM A 123.
   1. Hot-dip galvanize iron and steel hardware indicated to be galvanized to comply with ASTM A 153.

B. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

C. Preparation for Shop Priming: After galvanizing, thoroughly clean ornamental metal of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.

D. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed ornamental metal:
   1. Exteriors (SSPC Zone 1B): SSPC-SP 6, "Commercial Blast Cleaning."
   2. Interiors (SSPC Zone 1A): SSPC-SP 7, "Brush-off Blast Cleaning."

E. Factory-Primed Finish: Apply air-dried primer immediately after cleaning and pretreatment, to provide a minimum dry film thickness of 2 mils per applied coat, to surfaces that will be exposed after assembly and installation, and to concealed, nongalvanized surfaces.

F. Baked-Enamel Finish:
   1. Primer: Kem Hi-Temp Heat-Flex II 450 Primer by Sherwin-Williams, or equal.
   2. Finish coat: Kem Hi-Temp Heat-Flex 450 Finish by Sherwin-Williams, or equal.
   3. Porcelain Enamel Finish: PEI S-100, Specification for Architectural Porcelain Enamel on Steel for Exterior Use: Class AA or Class A.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Remove foreign substances and irregularities from surfaces against which metalwork is to be placed.

3.02 INSTALLATION, GENERAL:

A. Coordinate installation of ornamental metalwork with work of other trades. Provide anchorage devices and fasteners where necessary for securing ornamental metal to in-place construction.

B. Perform cutting, drilling, and fitting required to install ornamental metal. Set products accurately in location, alignment, and elevation; measured from established lines and levels. Provide temporary bracing or anchors in formwork for items to be built into concrete, masonry, or similar construction.

C. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, with uniform reveals and spaces for sealants and joint fillers. Where cutting, welding, and grinding are required for proper shop fitting and jointing of ornamental metal, restore finishes to eliminate any evidence of such corrective work.

D. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.

E. Fasten metalwork in place so that items will not be distorted, finish will not be impaired, nor fasteners over stressed from expansion and contraction of metal.

F. Protect exposed metalwork throughout work to prevent scratches, stains, discoloration and other damage. Restore protective coverings that have been damaged during shipment or installation. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.
1. Retain protective coverings intact; remove coverings simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration.

G. Field Welding: Comply with applicable AWS specification for procedures of manual shielded metal arc welding, for appearance and quality of welds, and for methods used in correcting welding work. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Grind exposed welded joints smooth and restore finish to match finish of adjacent surfaces.

H. Provide protection against galvanic action between dissimilar metals by completely covering contact surfaces with heavy brush-coat of bituminous paint or by separating contact surfaces with preformed tape.

I. Apply heavy brush-coat of bituminous paint to contact surfaces of ornamental metals, except stainless steel, which come into contact with concrete, mortar or other masonry. Do not apply paint onto concrete or masonry surfaces. Apply to metal, let cure, then apply metal fabrication to concrete or masonry.

3.03 INSTALLING HANDRAILS AND RAILINGS:

A. Adjust handrails and railings before anchoring to ensure alignment at abutting joints.

B. Concrete-Anchored Posts in Sleeves: Insert posts in preset sleeves, cast into concrete, and fill annular space between posts and sleeve with epoxy grout.
1. Remove contaminants from surfaces receiving and coming into contact with the grout. Remove surface contaminants such as curing compounds from holes that receive grout. Ensure that surfaces to receive grout are dry at the time of grouting.
2. Prime surfaces in accordance with grout manufacturer's recommendations.
3. Mix and place epoxy grout for locations shown or specified as recommended by grout manufacturer. Level exposed surfaces of grout joints with adjacent surfaces. Grind rough or raised projections smooth and flush with adjacent surfaces. Retain paragraph above or below or delete both if no posts in concrete.

C. Anchor posts to metal surfaces with fittings designed for this purpose.

D. Non-welded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of handrails and railing

E. Welded Connections: Use fully welded joints for permanently connecting railing components by welding. Cope or butt components to provide 100 percent contact or use fittings designed for this purpose.

F. Anchor railing ends into concrete or masonry with fittings designed for this purpose.

G. Anchor railing ends to metal surfaces with fittings using concealed fasteners.

H. Anchor railing ends to metal surfaces by welding.

I. Expansion Joints: Provide expansion joints at locations indicated or, if not indicated, at intervals not to exceed 40 feet. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.04 CLEANING:

A. Upon completion of installation, clean surfaces of metalwork by procedure recommended by metalwork manufacturer.

B. Clean up rubbish and debris caused by this work and remove from the site.

3.05 PROTECTION:

A. Protect finishes of ornamental metal from damage during construction period with temporary protective coverings approved by ornamental metal fabricator. Remove protective covering at the time of Substantial Completion.

B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION

SECTION 05810

EXPANSION JOINT COVER ASSEMBLIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing expansion joint cover assemblies.

B. Related Work Specified Elsewhere:
1. Cast-In-Place Structural Concrete: Section 03300.
2. Expansion Joint Systems: Section 05811.
3. Flashing and Sheet Metal: Section 07600.
4. Seals and Sealants: Section 07900.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements specified for each:
1. Product data for each type of expansion joint cover assembly specified, including manufacturer's product specifications, installation instructions, details of construction relative to materials, dimensions of individual components, profiles, and finishes.
2. Shop drawings showing fabrication and installation of expansion joint cover assembly including plans, elevations, sections, details of components, joints, splices, and attachments to other units of Work.
3. Samples for initial selection purposes in the form of manufacturer's color charts, actual units, or sections of units showing full range of colors, textures, and patterns available for each exposed metal and elastomeric material of expansion joint cover assembly indicated.
4. Samples for verification purposes in full-size units of each type of expansion joint cover assembly indicated; in sets for each finish, color, texture, and pattern specified, showing full range of variations expected in these characteristics.
    a. Install elastomeric material for joints samples to verify color selected.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ADA: Americans with Disabilities Act.
3. AAMA: 603.8, 605.2, 606.1, 607.1, 608.1
4. ANSI/UL: 263.
5. ASTM: A167, B209, B221, B455, C920, D2000, E119, E1399.
6. NAAMM: Metal Finishes Manual.
7. NFPA: 251.
8. UBC: 43-1.

B. Single-Source Responsibility: Where practical, obtain expansion joint cover assemblies specified in this Section from one source from a single manufacturer. Coordinate compatibility with expansion joint cover assemblies specified in other sections.

C. Fire-Test-Response Characteristics: Where indicated, provide expansion joint cover assemblies identical to those assemblies whose fire resistance has been determined per ANSI/UL 263, NFPA 251, U.B.C. 43-1, or ASTM E119, including hose stream test of vertical wall assemblies, by a testing and inspecting agency acceptable to authorities having jurisdiction.
1. Fire-Resistance Ratings: Not less than the rating of adjacent construction.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Aluminum: ASTM B221, alloy 6063-T5 for extrusions; ASTM B209, alloy 6061-T6, sheet and plate.
   1. Protect aluminum surfaces to be placed in contact with cementitious materials with a protective coating.

B. Bronze: ASTM B455, alloy C38500 for extrusions; alloy C28000 Muntz Metal for plates.

C. Brass: UNS alloy C26000 for half hard sheet and coil.

D. Stainless Steel: ASTM A167, Type 304 with 2B finish, unless indicated otherwise, for plates, sheet, and strips.

E. Extruded Preformed Seals: Single or multicellular elastomeric profiles as classified under ASTM D2000, designed with or without continuous, longitudinal, internal baffles. Formed to fit compatible frames, in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors.

F. Preformed Sealant: Manufacturer's standard elastomeric sealant complying with ASTM C920, Use T, factory-formed and -bonded to metal frames or anchor members; in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors.
   1. Joints 2 Inches Wide and Less: Withstand plus or minus 35 percent movement of the joint width without failure.
   2. Joints Greater Than 2 Inches to 4 Inches Wide: Withstand plus or minus 50 percent movement of the joint width without failure.

G. Seismic Seals: Typically for exterior application, two single-layered elastomeric profiles, one interior and one exterior, as classified under ASTM D2000; retained in a set of compatible frames, in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors. At manufacturer's option, omit interior profile for interior application.

H. Fire Barriers: Designed for indicated or required dynamic structural movement without material degradation or fatigue when tested according to ASTM E1399. Tested in maximum joint width condition with a field splice as a component of an expansion joint cover per ANSI/UL 263, NFPA 251, U.B.C. 43-1, or ASTM E119, including hose stream test of vertical wall assemblies by a nationally recognized testing and inspecting agency acceptable to authorities having jurisdiction.

I. Accessories: Manufacturer's standard anchors, fasteners, set screws, spacers, flexible moisture barrier and filler materials, drain tubes, lubricants, adhesive, and other accessories compatible with material in contact, as indicated or required for complete installations.

2.02 EXPANSION JOINT COVER ASSEMBLIES:

A. General: Provide expansion joint cover assemblies of design, basic profile, materials, and operation indicated on approved shop drawings. Provide units comparable to those indicated or required to accommodate joint size, variations in adjacent surfaces, and dynamic structural movement without material degradation or fatigue when tested according to ASTM E1399. Furnish units in longest practicable lengths to minimize number of end joints. Provide hairline mitered corners where joint changes directions or abuts other materials. Include closure materials and transition pieces, tee-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous joint cover assemblies.

B. Moisture Barrier: Provide manufacturer's continuous, standard, flexible vinyl moisture barrier under covers at locations indicated on approved shop drawings.

C. Fire-Rated Joint Covers: Provide expansion joint cover assemblies with manufacturer's continuous, standard, flexible fire barrier seals under covers at locations indicated on approved shop drawings to provide fire-resistive rating not less than the rating of adjacent construction.

D. Coverless Fire Barrier: Provide manufacturer's continuous standard flexible fire barrier seals at locations indicated on approved shop drawings to provide fire-resistive rating not less than the rating of adjacent construction.

E. Metal Floor-to-Floor Joint Cover Assemblies: Provide continuous extruded metal frames of profile indicated with seating surface and raised floor rim or exposed trim strip to accommodate flooring and concealed bolt and anchors embedded in concrete. Provide assemblies formed to receive cover plates of design indicated and to receive filler materials (if any) between raised rim of frame and edge of plate. Furnish depth and configuration to suit type of construction and to produce a continuous flush wearing surface with adjoining finish floor surface.
   1. Partially Concealed Cover: Provide one frame on each side of joint, designed to accommodate manufacturer's floor cover plate and filler.
   2. Exposed Cover: Provide one frame on each side of joint, designed to support floor plate and filler
   3. Flat Cover Plates: Provide cover plates of profile and wearing surface indicated. Extend flat plates to lap each side of joint.
      a. Filler Insert: Furnish abrasive-resistant flexible gasket filler between edge of cover plate and raised rim of frame to accommodate required movement
   4. Fixed Cover Plates: Attach one side of the cover plate to a frame or finished wearing surface, with other side resting on other frame or finished wearing surface to allow free movement.
   5. Self-Centering Cover Plates: Concealed centering device with the cover plate secured in or on top of frames as to have free movement on both sides.
   6. Floor Cover Plate Wearing Surfaces: Provide cover plates with the following type of wearing surfaces.
      a. Plain.
      b. Fluted.
      c. Recessed to receive full thickness of flooring material.
      d. Abrasive plate.
      e. Adhesive filled plate.
      f. Adhesive strip plate.

F. Floor-to-Wall Joints: Provide one frame on floor side of joint only. Provide wall side frame where required by manufacturer's design.
   1. Angle Cover Plates: Attach angle cover plates for floor-to-wall joints to wall with countersunk, flat-head exposed fasteners secured to drilled-in-place anchor shields, unless otherwise indicated, at spacing recommended by joint cover manufacturer.

G. Wall, Ceiling, and Soffit Joint Cover Assemblies: Provide interior wall and ceiling expansion joint cover assemblies of same design and appearance. Provide exterior wall and soffit expansion joint cover assemblies of same design and appearance. Provide wall expansion joint cover assemblies compatible with floor expansion joint cover assemblies design and appearance.
   1. Fixed Metal Cover Plates: Provide a concealed, continuously anchored frame fastened to wall, ceiling, or soffit only on one side of joint. Extend cover to lap each side of joint and to permit free movement on one side. Attach cover to frame with cover in close contact with adjacent finish surfaces.

2. Floating Metal Cover Plates: Cover plate secured in or on top of frames to permit free movement on both sides.
3. Self-Centering Cover Plates: Concealed centering device with the cover plate secured in or on top of frames to permit free movement on both sides.
4. Flexible Filler: Secure the approved flexible filler between frames to compress and expand with movement.

H. Joint Cover Assemblies with Preformed Seals: Provide joint cover assemblies consisting of continuously anchored aluminum extrusions and continuous extruded preformed seals of profile indicated or required to suit types of installation conditions shown. Furnish extrusions designed to be embedded in or attached to concrete with lugs. Vulcanize or heat-weld splices (if any) to ensure hermetic joint condition.
1. Cover Plate: Include extruded aluminum cover plate fastened to one side of joint and extend plate to lap each side of joint to permit free movement with cover in close contact with adjacent contact surfaces.

I. Joint Cover Assemblies with Elastomeric Sealant: Provide continuous cover joint assemblies consisting of elastomeric sealant factory-bonded to extruded aluminum frames of profile indicated or required to suit types of installation conditions shown. Provide frames for floor joints with means for embedding in or anchoring to concrete without using exposed fasteners and that will result in exposed surfaces of sealant and aluminum frames finishing flush with adjacent finished floor surface without exposing anchors.

J. Compression Seals: Preformed, elastomeric extrusions having internal baffle system in sizes and profiles shown or as recommended by the manufacturer. Provide lubricant and adhesive for installation recommended by the manufacturer.

K. Foam Seal: Nonextruded, low-density, cross-linked, nitrogen-blown ethylene vinyl acetate polyethylene copolymer foam. Provide adhesive for installation recommended by the manufacturer.

2.03 METAL FINISHES:

A. General: Comply with NAAMM "Metal Finishes Manual" for finish designations and application recommendations, except as otherwise indicated. Apply finishes to products in factory after fabrication. Protect finishes on exposed surfaces before shipment.

B. Aluminum Finishes: Finish designations prefixed by AA conform to the system established by the Aluminum Association for designating aluminum finishes.
1. Mill Finish: AA-M10 (unspecified mill finish).
2. Class II, Clear-Anodized Finish: AA-M12C22A31 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class II Architectural, clear film thicker than 0.4 mil].
3. Class I, Clear-Anodized Finish: AA-M12C22A41 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class I Architectural, clear film thicker than 0.7 mil[complying with AAMA 607.1.
4. Class II, Color-Anodized Finish: AA-M12C22A32/A34 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class II Architectural, film thicker than 0.4 mil with integral color or electrolytically deposited color].
5. Class I, Color-Anodized Finish: AA-M12C22A42/A44 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class I Architectural, film thicker than 0.7 mil with integral color or electrolytically deposited color] complying with AAMA 606.1 or AAMA 608.1.
   a. Color: As selected by the Engineer from within standard industry colors and color density range.
6. Baked Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited

chemicals; Chemical Finish: chemical conversion coating, acid chromate-fluoride-phosphate pretreatment; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.

a. Organic Coating: Thermosetting modified acrylic enamel primer/topcoat system complying with AAMA 603.8 except with minimum dry film thickness of 1.5 mils, medium gloss

b. Color: As selected by the Engineer from manufacturer's standard colors.

7. High-Performance Organic Coating: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: chemical conversion coating, acid chromate-fluoride-phosphate pretreatment; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturer's instructions.

a. Fluoropolymer Two-Coat Coating System: Manufacturer's standard two-coat thermocured system, composed of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.

b. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat thermocured system composed of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluorocarbon topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.

1) Resin Manufacturers: Subject to compliance with requirements, provide fluoropolymer coating systems containing resins produced by one of the following manufacturers:

a) Ausimont USA, Inc. (Hylar 5000).

b) Elf Atochem North America, Inc. (Kynar 500).

c) Or equal.

2) Color and Gloss: As selected by the Engineer from manufacturer's standard choices for color and gloss.Retain below for covers in contact with masonry or concrete.

8. Factory-Primed Concealed Surfaces: Protect concealed metal surfaces to be placed in contact with concrete or masonry with a shop coat of manufacturer's standard primer on the contact surfaces.

C. Bronze Finish: Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes.

1. Natural Satin Finish: CDA Designation M32, mechanical finish, directional textured, medium satin.

D. Stainless Steel Finishes: Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes.

1. Bright, Cold-Rolled Unpolished Finish: AISI No. 2B finish.
2. Bright, Directional Polish: AISI No. 3 finish.

E. Factory Finish: Manufacturer's standard factory finish.

PART3 - EXECUTION

3.01 PREPARATION:

A. Manufacturer's Instructions: In addition to requirements of these specifications, comply with manufacturer's instructions and recommendations for phases of Work, including preparing substrate, applying materials, and protecting installed units.

B. Coordinate and furnish anchorages, setting drawings, templates, and instructions for installation of expansion joint cover assemblies to be embedded in or anchored to concrete

or to have recesses formed into edges of concrete slab for later placement and grouting-in of frames.

C. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary to secure expansion joint cover assemblies to in-place construction, including threaded fasteners with drilled-in expansion shields for masonry and concrete where anchoring members are not embedded in concrete. Provide fasteners of metal, type, and size to suit type of construction indicated and provide for secure attachment of expansion joint cover assemblies.

3.02 INSTALLATION:

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required to install expansion joint covers. Install joint cover assemblies in true alignment and proper relationship to expansion joints and adjoining finished surfaces measured from established lines and levels. Allow adequate free movement for thermal expansion and contraction of metal to avoid buckling. Set floor covers at elevations to be flush with adjacent finished floor materials. Locate wall, ceiling, roof, and soffit covers in continuous contact with adjacent surfaces. Securely attach in place with required accessories. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches on center.

B. Continuity: Maintain continuity of expansion joint cover assemblies with a minimum number of end joints and align metal members mechanically using splice joints. Cut and fit ends to produce joints that will accommodate thermal expansion and contraction of metal to avoid buckling of frames. Adhere flexible filler materials (if any) to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.

C. Extruded Preformed Seals: Install seals complying with manufacturer's instructions and with minimum number of end joints. For straight sections provide preformed seals in continual lengths. Vulcanize or heat-weld field splice joints in preformed seal material to provide watertight joints using procedures recommended by manufacturer. Apply adhesive, epoxy, or lubricant-adhesive approved by manufacturer to both frame interfaces before installing preformed seal. Seal transitions according to manufacturer's instructions.

D. Elastomeric Sealant Joint Assemblies: Seal end joints within continuous runs and joints at transitions according to manufacturer's directions to provide a watertight installation.

E. Seismic Seals: Install interior seals in continual lengths; vulcanize or heat-weld field splice joints in interior seal material to provide watertight joints using manufacturer's recommended procedures. Install exterior seal in standard lengths. Seal transitions and end joints according to manufacturer's instructions.

F. Fire Barriers: Install fire barriers, including transitions and end joints, according to manufacturer's instructions so that fire-rated construction is continuous.

3.03 CLEANING AND PROTECTION:

A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's instructions.

END OF SECTION

SECTION 05811

EXPANSION JOINT SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing exterior (pedestrian and vehicular) traffic joints, exterior (wall and ceiling) joints, exterior soffit joints, interior (pedestrian and vehicular) traffic joints, interior (wall anc ceiling) joints and interior soffit joints.

B. Related Work Specified Elsewhere:
1. Cast-In-Place Structural Concrete: Section 03300.
2. Expansion Joint Cover Assemblies: Section 05810.
3. Flashing and Sheet Metal: Section 07600.
4. Seals and Sealants: Section 07900.

1.02 DEFINITIONS:

A. Architectural Joint System: Any filler or cover used to span, fill, cover, or seal a joint, except expanding foam seals and poured or foamed in-place sealants.

B. Cyclic Movement: Periodic change between widest and narrowest joint widths in an automatically mechanically controlled system.

C. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist passage of flame and hot gases through a movement joint.

D. Maximum Joint Width: Widest linear gap a joint system tolerates and performs its designed function without damaging its functional capabilities.

E. Minimum Joint Width: Narrowest linear gap a joint system tolerates and performs its designed function without damaging its functional capabilities.

F. Movement Capability: Value obtained from the difference between widest and narrowest widths of a joint opening typically expressed in numerical values (inches) or a percentage of nominal value of joint width.

G. Nominal Joint Width: Width of linear gap indicated as representing the conditions existing when architectural joint systems will be installed or, if no nominal joint width is indicated, a width equal to the sum of maximum and minimum joint widths divided by two

1.03 PERFORMANCE REQUIREMENTS:

A. General: Provide factory-fabricated architectural joint systems capable of withstanding the types of loads and of accommodating the kinds of movement, and the other functions for which they are designed including those specified below, without failure. Types of failure include those listed in Appendix X3 of ASTM E1399.
1. Vehicular Traffic Joints: Support vehicular traffic across joint.
2. Pedestrian Traffic Joints: Support pedestrian traffic across joint.
3. Exterior Joints: Maintain continuity of weather enclosure.
4. Joints in Fire-Resistance-Rated Assemblies: Maintain fire-resistance ratings of assemblies.
5. Joints in Smoke Barriers: Maintain integrity of smoke barrier.

6. Joints in Acoustically Rated Assemblies: Inhibit passage of airborne noise.
7. Other Joints: Where indicated, provide joint systems that prevent penetration of water, moisture, and other substances deleterious to building components or content.
8. Seismic Joints: Remain in place on exposure to seismic activity (movement).
9. Joints in Surfaces with Architectural Finishes: Serve as finished architectural joint closures.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data: Include manufacturer's product specifications, construction details, material and finish descriptions, and dimensions of individual components and seals.
2. Shop Drawings: For each joint system specified, provide the following:
a. Placement Drawings: Include line diagrams showing entire route of each joint system, plans, elevations, sections, details, joints, splices, locations of joints and splices, and attachments to other Work. Where joint systems change planes, provide Isometric Drawings depicting how components interconnect to achieve continuity of joint covers and fillers.
3. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available for each exposed metal and elastomeric material of joint system indicated.
a. Include similar Samples of material for joints and accessories involving color selection.
4. Samples for Verification: Full-size units 6 inches long of each type of joint system indicated; in sets for each finish, color, texture, and pattern specified, showing the full range of variations expected in these characteristics.
5. Product Test Reports: From a qualified testing agency indicating architectural joint systems comply with requirements, based on comprehensive testing of current products.

1.05 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AAMA: 606.1, 607.1, 608.1, 2603, 2604, 2605.
3. ADA: Americans with Disabilities Act.
4. ASTM: A666, B36, B209, B221, B455, E119, E814, E1399, E1612, E1783.
5. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
6. UL: 2079.

B. Source Limitations: Where practical, obtain architectural joint systems through one source from a single manufacturer. Coordinate compatibility with adjoining joint systems specified in other Sections.

C. Fire-Test-Response Characteristics: Where indicated, provide joint systems incorporating fire barriers that are identical to those of assemblies tested for fire resistance per **[ASTM E 119] [and] [ASTM E 814] [UL 2079]**, including hose-stream test of vertical wall assemblies, by a testing and inspecting agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Aluminum: ASTM B221, alloy 6063-T5 for extrusions; ASTM B209, alloy 6061-T6 for sheet and plate.
   1. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.

B. Bronze: ASTM B455, alloy C38500 for extrusions; alloy C23000 Red Brass for plates.

C. Brass: ASTM B36/B36M, UNS alloy C26000 for half hard sheet and coil.

D. Stainless Steel: ASTM A666, Type 304 with No. 2B finish, unless otherwise indicated, for plates, sheet, and strips.

E. Preformed Seals: Single or multicellular extruded elastomeric seals designed with or without continuous, longitudinal, internal baffles. Formed to be installed in frames or with anchored flanges, in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors.

F. Preformed Silicon-Foam Sealant System: Section 07900.

G. Strip Seals: Elastomeric membrane or tubular extrusions with a continuous longitudinal internal baffle system throughout complying with ASTM E 1783; used with compatible frames, flanges, and molded-rubber anchor blocks.

H. Compression Seals: Preformed, elastomeric extrusions having internal baffle system complying with ASTM E1612 in sizes and profiles indicated or as recommended by manufacturer.

I. Preformed Cellular Foams: [Nonextruded, low-density, crosslinked, nitrogen-blown ethylene-vinyl-acetate copolymer] [Neoprene] [or] [polyurethane] extruded, compressible foam.

J. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint.

K. Accessories: Manufacturer's standard anchors, clips, fasteners, set screws, spacers, flexible moisture barrier and filler materials, drain tubes, lubricants, adhesives, and other accessories compatible with material in contact, as indicated or required for complete installations.

2.02 EXPANSION JOINT SYSTEMS:

A. General: Provide joint systems of design, basic profile, materials, and operation indicated on approved shop drawings. Provide units with the capability to accommodate joint widths indicated and variations in adjacent surfaces.
   1. Furnish units in longest practicable lengths to minimize number of end joints. Provide hairline mitered corners where joint changes directions or abuts other materials.
   2. Include closure materials and transition pieces, tee-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous joint systems.
   3. Frames for Strip Seals: Designed with semiclosed cavity that provides a mechanical lock for seals of type indicated.
   4. Public Arena Seals: Non-slip seals designed for installation on treads and risers and to lie flat with adjacent surfaces, and complying with ADA guidelines for public areas.

5. Cyclic-Movement-Test-Response Characteristics: No evidence of visual fatigue, inability to cycle between designated joint widths, or other types of failure as determined by testing products identical to those indicated per ASTM E1399 including Appendix X3.
6. Fire-Resistance Ratings: Provide manufacturer's standard fire barrier with a rating not less than that of adjacent construction.
7. Moisture Barrier: Provide manufacturer's standard unit.

2.03 FINISHES, GENERAL:

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.04 ALUMINUM FINISHES:

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. Mill Finish: AA-M10 (Mechanical Finish: as fabricated; no other applied finish unless buffing is required to remove scratches, welding, or grinding produced in fabrication process.

C. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 607.1.

D. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 607.1.

E. Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).

F. Class I, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 606.1 or AAMA 608.1.
1. Color: As selected by the Engineer from the full range of industry colors and color densities.

G. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.
1. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 1.5 mils, medium gloss.
2. Color: As selected by the Engineer from manufacturer's full range.

H. High-Performance Organic Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic

Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2604.
2. Fluoropolymer Three-Coat System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2605.
    a. Color and Gloss: As selected by the Engineer from manufacturer's full range.

2.05 STAINLESS STEEL FINISHES:

A. Remove tool and die marks and stretch lines or blend into finish.

B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

C. Bright, Cold-Rolled, Unpolished Finish: No. 2B finish.

D. Bright, Directional Polish: No. 4 finish.

E. Satin, Directional Polish: No. 6 finish.

F. Mirrorlike Reflective, Nondirectional Polish: No. 8 finish.

G. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.06 COPPER ALLOY FINISHES:

A. Finish designations prefixed by CDA comply with the system established by the Copper Development Association for designating copper-alloy finish systems, as defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
    1. Remove tool and die marks and stretch lines or blend into finish.
    2. Grind and polish surfaces to produce uniform, directionally textured polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

B. Standard Finish Designation: CDA M32 (Mechanical Finish: directionally textured, medium satin).

PART 3 - EXECUTION

3.01 PREPARATION:

A. Prepare substrates according to architectural joint system manufacturer's written instructions.

B. Coordinate and furnish anchorages, Placement Drawings, and instructions for installing joint systems to be embedded in or anchored to concrete or to have recesses formed into edges of concrete slab for later placement and grouting-in of frames.

C. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary to secure joint systems to in-place construction, including threaded fasteners with drilled-in expansion shields for masonry and concrete where anchoring members are not embedded in concrete. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of joint systems.

3.02 INSTALLATION:

A. Comply with manufacturer's written instructions for handling and installing architectural joint assemblies and materials, unless more stringent requirements are indicated.

B. Coordinate installation of architectural joint assembly materials and associated work so complete assemblies comply with assembly performance requirements.

C. Terminate exposed ends of exterior architectural joint assemblies with factory-fabricated termination devices to maintain waterproof system.

D. Install factory-fabricated transitions between building expansion joint cover assemblies and roof expansion joint assemblies to provide continuous, uninterrupted, watertight construction.

E. Coordinate the size of joint opening at the time joint segments are set in position (distance between joint segments) with the temperature of the structure and the designed joint movement.

F. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required to install joint systems.
1. Install joint cover assemblies in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
2. Allow adequate free movement for thermal expansion and contraction of metal to avoid buckling.
3. Set covers in horizontal surfaces at elevations that place exposed surfaces flush with adjoining finishes.
4. Locate covers in continuous contact with adjacent surfaces.
5. Securely attach in place with required accessories.
6. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches o.c.

G. Continuity: Maintain continuity of joint systems with a minimum number of end joints and align metal members. Cut and fit ends to produce joints that will accommodate thermal expansion and contraction of metal to avoid buckling of frames. Adhere flexible filler materials, if any, to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.

H. Extruded Preformed Seals: Install seals to comply with manufacturer's written instructions and with minimum number of end joints.
1. For straight sections, provide preformed seals in continuous lengths.
2. Vulcanize or heat-weld field splice joints in preformed seal material to provide watertight joints using procedures recommended by manufacturer.
3. Apply adhesive, epoxy, or lubricant adhesive approved by manufacturer to both frame interfaces before installing preformed seals.
4. Seal transitions according to manufacturer's written instructions.
5. Install foam seals with adhesive recommended by manufacturer and heat seal all splices.

I. Joint Systems with Seals: Seal end joints within continuous runs and joints at transitions according to manufacturer's written instructions to provide a watertight installation.

J. Seismic Seals: Install interior seals in continuous lengths. Install exterior seal in standard lengths and vulcanize or heat-weld field splice joints to provide watertight joints using manufacturer's recommended procedures. Seal transitions and end joints according to manufacturer's written instructions.

K. Fire Barriers: Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and end joints.

3.03 CLEANING AND PROTECTION:

A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.

END OF SECTION

SECTION 06075

WOOD PRESERVATIVE TREATMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies preservative treatment of timber and lumber where shown.

B. Unless otherwise shown, apply preservative treatments as follows:
   1. Creosote: Apply creosote treatment to wood which meets all of the following :
      a. Is to be in contact with water or earth.
      b. Is to be exposed to weather but not painted.
      c. Is not subject to handling after installation.
   2. Pentachlorophenol and copper naphthenate: Apply pentachlorophenol and copper naphthenate treatment to wood which meets all of the following:
      a. Is exposed to the weather.
      b. May or may not be painted.
      c. Is subject to handling after installation.
   3. Water-borne preservatives:
      a. Use in approved locations.

C. Definitions:
   1. PPT: Pressure-preservative treated.
   2. FRT: Fire-retardant treated.
   3. MSDS: Material safety data sheets.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Product Data: Manufacturer's product data and MSDS, including instructions for handling, storing, installing and finishing treated material.

B. Certification: Submit certification that furnished meet specified requirements with each shipment of treated timber and lumber.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AWPA Standards: C2, C3, C9, C20, C27, C35, M4, P1, P2, P5, P8, P17.

B. Source Quality Control:
   1. Use only preservative treatment materials which have been tested and approved.
   2. After treatment have each piece of material stamped with the American Wood Preserver's Institute Quality Mark to indicate compliance with specified requirements.
   3. Inform the Engineer when treated wood is ready for inspection.
   4. Ship treated wood only after inspection and approval.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Handling:
   1. Handle treated items with rope slings or other approved means. Do not drop, bruise, break outer fibers or penetrate surface with sharp tools.
   2. When stacking timber, avoid use of sharp tools for handling or turning in leads.

B. Storage:
   1. Ensure that storage area has been cleared of debris and vegetation to at least four feet beyond limits of stored materials.
   2. Provide drainage away from stored materials.
   3. Store piles of timber and lumber so as to permit ready access and free air circulation.
   4. Store treated timber and lumber at least 12 inches above surface of ground.
   5. Stack ties no more than 20 layers high nor 10 feet wide.

PART 2 MATERIALS:

2.01 MATERIALS:

A. Creosote: AWPA P1.

B. Creosote and Coal-Tar Solution: Coal-tar distillate or solution of coal tar in coal-tar distillate conforming to AWPA P2.

C. Pentachlorophenol: AWPA P8.

D. Copper Naphthenate: AWPA P8..

E. Waterborne Preservatives: AWPA P5.

F. Fire Retardant Formulations: AWPA P17.

PART 3 - EXECUTION

3.01 TREATMENT:

A. General:
   1. Prior to treating timber and lumber, perform fitting, cutting, drilling and mortising of joints.
   2. After treatment, kiln-dry lumber and plywood to a maximum moisture content of 19 and 15 respectively.

B. Pressure treat timber and lumber in accordance with AWPA C2. For creosote, creosote solutions and oil-borne preservatives, use empty-cell treatment. If retention specified is greater than can be obtained by empty-cell process, inject water-borne preservative by full-cell process.

C. Piles: Unless otherwise shown, apply creosote treatment to timber piles in accordance with AWPA C3.

D. Poles: Unless otherwise shown, apply creosote treatment to timber poles in accordance with AWPA C35.

E. Plywood (PPT): Pressure preservative treat plywood where indicated in accordance with AWPA C9.

F. Plywood (FRT): Pressure fire retardant treat plywood where indicated in accordance with AWPA C27.

G. Miscellaneous Wood Framing: Treat indicated items and the following in accordance with AWPA C2.
1. Wood cants, nailers, curbs , equipment support bases, blocking stripping and similar members in connection with roofing, flashing, vapor barriers and waterproofing.
2. Wood sills, sleepers, blocking, furring, stripping and similar concealed membrane in contact with masonry or concrete.
3. Wood framing members less than 18 inches above grade.
4. Wood floor plates installed over concrete slabs directly in contact with earth.

H. Fire-Retardant Treatment for Lumber (FRT): Fire-retardant wood treatment in accordance with AWPA C20.

I. Incising:
1. For lumber with least dimension between two inches and three inches, incise wide faces by means of suitable power-driven machine prior to treatment.
2. For timber with least dimension in excess of three inches, incise all four faces.

3.02 TREATMENT OF FIELD CUTS:

A. Treat bare surfaces resulting from drilling, cutting, tapping or damage of timber and lumber in accordance with AWPA M4.

B. Apply same treatment to cutoff surfaces of timber piles not embedded in concrete.

END OF SECTION

SECTION 06100

ROUGH CARPENTRY

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies rough carpentry for wood blocking, roof sheathing, rooftop equipment bases and support curbs, miscellaneous lumber and accessories.

B. Related Work Specified Elsewhere:
1. Wood Preservative Treatment: Section 06075.
2. Roof Accessories: Section 07730.
3. Flashing and Sheet Metal: Section 07600.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

B. Product Data for metal framing anchors and construction adhesives.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

B. Comply with codes and regulations of the jurisdictional authorities.
1. ALSC: NGR.
2. DOC PS20.
3. AWPA C2, C9, C20, C27, M4.
4. UL.
5. APA.
6. FS FF-N-105.
7. CAB NER-272.
8. ASME A153, A307, A563, A653, B18.6.1, B18.2.1

1.04 DELIVERY, STORAGE, AND HANDLING:

A. Keep materials under cover and dry. Protect from weather and contact with damp or wet surfaces. Stack lumber, plywood, and other panels. Provide for air circulation within and around stacks and under temporary coverings.
1. For lumber and plywood pressure treated with waterborne chemicals, place spacers between each bundle to provide air circulation.

PART 2 - PRODUCTS

2.01 LUMBER, GENERAL:

A. Lumber Standards: Comply with DOC PS 20, "American Softwood Lumber Standard," and with applicable grading rules of inspection agencies certified by American Lumber Standards Committee's (ALSC) Board of Review.

B. Dressed sizes of green lumber are larger than dry lumber under DOC PS 20.Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

2.02 WOOD-PRESERVATIVE-TREATED MATERIALS:

A. General: Where lumber or plywood is indicated as preservative treated or is specified to be treated, comply with applicable requirements of AWPA C2 (lumber) and AWPA C9 (plywood). Mark each treated item with the Quality Mark Requirements of an inspection agency approved by ALSC's Board of Review.
   1. Do not use chemicals containing chromium or arsenic.

B. Pressure treat aboveground items with waterborne preservatives to a minimum retention of 0.25 lb/cu. ft.. After treatment, kiln-dry lumber and plywood to a maximum moisture content of 19 and 15 percent, respectively. Treat indicated items and the following:
   1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
   2. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
   3. Wood framing members less than 18 inches above grade.
   4. Complete fabrication of treated items before treatment, where possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.

2.03 FIRE-RETARDANT-TREATED MATERIALS:

A. General: Where fire-retardant-treated wood is indicated, comply with applicable requirements of AWPA C20 (lumber) and AWPA C27 (plywood). Identify fire-retardant-treated wood with appropriate classification marking of UL; U.S. Testing; Timber Products Inspection, Inc.; or another testing and inspecting agency acceptable to authorities having jurisdiction.
   1. Research or Evaluation Reports: Provide fire-retardant-treated wood acceptable to authorities having jurisdiction and for which a current model code research or evaluation report exists that evidences compliance of fire-retardant-treated wood for application indicated.

B. Interior Type A: For interior locations, use chemical formulation that produces treated lumber and plywood with the following properties under conditions present after installation:
   1. Bending strength, stiffness, and fastener-holding capacities are not reduced below values published by manufacturer of chemical formulation under elevated temperature and humidity conditions simulating installed conditions when tested by a qualified independent testing agency.
   2. No form of degradation occurs due to acid hydrolysis or other causes related to treatment.
   3. Contact with treated wood does not promote corrosion of metal fasteners.

2.04 DIMENSION LUMBER:

A. General: Provide dimension lumber of grades indicated according to the ALSC National Grading Rule (NGR) provisions of the inspection agency indicated.

2.05 MISCELLANEOUS LUMBER:

A. General: Provide lumber for support or attachment of other construction, including rooftop equipment curbs and support bases, cant strips, bucks, nailers, blocking, furring, grounds, stripping, and similar members.

B. Fabricate miscellaneous lumber from dimension lumber of sizes indicated and into shapes shown.

C. Moisture Content: 19 percent maximum for lumber items not specified to receive wood preservative treatment.

2.06 ROOF SHEATHING:

A. General: Where structural-use panels are indicated for the following concealed types of applications, provide American Plywood Association (APA)-performance-rated panels complying with requirements designated under each application for grade, span rating, exposure durability classification, and edge detail (where applicable).
   1. Thickness: Provide panels meeting requirements specified but not less than thickness indicated.
   2. Span Ratings: Provide panels with span ratings required to meet "Code Plus" provisions of APA Form No. E30, "APA Design/Construction Guide: Residential & Commercial."

2.07 FASTENERS:

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
   1. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with a hot-dip zinc coating per ASTM A 153 or of Type 304 stainless steel.

B. Nails, Wire, Brads, and Staples: FS FF-N-105.

C. Power-Driven Fasteners: CABO NER-272

D. Wood Screws: ASME B18.6.1

E. Lag Bolts: ASME B18.2.1.

F. Bolts: Steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated, flat washers.

2.08 METAL FRAMING ANCHORS:

A. General: Provide galvanized steel framing anchors of structural capacity, type, and size indicated and as follows:
   1. Research or Evaluation Reports: Provide products for which model code research or evaluation reports exist that are acceptable to authorities having jurisdiction and that evidence compliance of metal framing anchors for application indicated with building code in effect for Project.
   2. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis, and demonstrated by comprehensive testing performed by a qualified independent testing agency.

B. Galvanized Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A 653, G60 coating designation; structural, commercial, or lock-forming quality, as standard with manufacturer for type of anchor indicated.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL:

A. Discard units of material with defects that impair quality of rough carpentry and that are too small to use with minimum number of joints or optimum joint arrangement.

B. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted.

C. Fit rough carpentry to other construction; scribe and cope as required for accurate fit. Correlate location of furring, nailers, blocking, grounds, and similar supports to allow attachment of other construction.

D. Apply field treatment complying with AWPA M4 to cut surfaces of preservative-treated lumber and plywood.

E. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
1. Counsel of American Building Officials: CABO NER-272 for power-driven staples, P-nails, and allied fasteners.
2. Published requirements of metal framing anchor manufacturer.

F. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; predrill as required.

G. Use hot-dip galvanized or stainless-steel nails where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity.

3.02 WOOD GROUNDS, NAILERS, BLOCKING, AND SLEEPERS:

A. Install wood nailers, blocking, and sleepers where shown and where required for screeding or attaching other work. Form to shapes shown and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated. Build into masonry during installation of masonry work. Where possible, anchor to formwork before concrete placement.

END OF SECTION

SECTION 07110

DAMPPROOFING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing dampproofing.

B. Related Work Specified Elsewhere:
   1. Cast-in-Place Structural Concrete: Section 03300.
   2. Cast-in-Place Architectural Concrete: Section 03331

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Product data for each type of product specified, including data substantiating that materials comply with requirements for each dampproofing material specified. Include recommended method of application, recommended primer, number of coats, coverage or thickness, and recommended protection course.

B. Certification:
   1. Certification that materials furnished meet specified requirements and are compatible with each other.
   2. Certification by dampproofing manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs).

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Codes and regulations of the jurisdictional authorities.
   2. ASTM: D41, D449.

B. Demonstration Area:
   1. Prepare 100-square foot specimen of typical dampproofing application using specified methods and materials.
   2. Location of demonstration area as directed. Dampproofing will be visually and physically examined by the Engineer.
   3. If demonstration area is disapproved, prepare additional demonstration area. Do not proceed with dampproofing until demonstration area has been approved. Approved demonstration area will serve as the standard of quality and workmanship for dampproofing work specified in this section.

C. Installer Qualifications: Engage an experienced Installer who has completed bituminous dampproofing similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to the jobsite in their original unopened containers clearly labeled with manufacturer's name, brand designation, referenced specification number, type and class, as applicable.

B. Store products in approved dry area, protected from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Application of dampproofing to unprotected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible is prohibited.
2. Application of dampproofing when ambient temperature is below 40F is prohibited.

B. Substrate: Proceed with dampproofing only after substrate construction and penetrating work have been completed.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Asphalt Primer: ASTM D41.

B. Asphalt: ASTM D449, Type A.

C. Portland Cement Grout: Section 04050.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Do not start dampproofing until requirements for curing concrete have been completed and surfaces have thoroughly dried.

B. Clean surfaces to be dampproofed of loose and foreign material, concrete fins and dirt.

C. Moisten and point holes, honeycombs, cracks, cavities and concrete fill with portland cement grout and allow to cure completely before covering. See Section 03300 for curing and protection.

3.02 APPLICATION:

A. Apply dampproofing, consisting of two prime coats and one seal coat of dampproofing materials, to surfaces shown to receive dampproofing.
1. Apply two coats of primer to surfaces to be dampproofed at rate of one gallon per 100 square feet. Allow first coat to dry thoroughly before second coat is applied.
2. Do not heat prime-coat material for application.
3. After second prime coat has thoroughly dried, brush one coat of hot asphalt as applicable over primed surface at minimum rate of 15 pounds per 100 square feet of surface; fill cracks, voids and crevices.
4. Do not heat asphalt in excess of 400F.
5. Apply dampproofing coat so as to ensure continuous surface free of dull or porous spots. Give dull or porous spots additional coating of hot asphalt.
6. Perform finished work to conform to dimensions shown; do not disfigure other areas or parts of structure by dripping or spreading of materials.

3.03 PROTECTING AND CLEANING:

A. Protect finish work during application of dampproofing and repair damage.

B. Remove spots and spattering of the dampproofing from finish work and leave the entire work area in first-class condition.

C. Remove dampproofing rubbish from the premises and leave spaces in broom-clean condition.

END OF SECTION

SECTION 07125

MEMBRANE WATERPROOFING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing fluid-applied membrane waterproofing, rubberized-asphalt sheet membrane waterproofing and protection courses.

B. Related Work Specified Elsewhere:
1. Cast-in-Place Structural Concrete: Section 03300.
2. Cast-in-Place Architectural Concrete: Section 03331.
3. Brick: Section 04215.
4. Concrete block: Section 04220.
5. Mortar: Section 04050.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data: Include manufacturer's written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties of waterproofing.
2. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins to adjoining waterproofing, and other termination conditions.
   a. Include joint and anchorage details, materials and description of sequence of operation.
3. Samples: Four of each type of the following materials used in the work:
   a. Membrane: 12 inches square.
   b. Adhesive: Half-pint containers.
   c. Butyl gum tape: Small rolls.
   d. Hardboard: 12 inches square.
   e. Protection board: 12 inches square.

B. Certification:
1. Certification that materials furnished meet specified requirements and are compatible with each other.
2. Certification that the applicator is approved by the manufacturer.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American Hardboard Association Industry: AHAI Standard 1.
3. FS: TT-S-230.
4. ASTM: A123, C42, C78, C90, C171, C192, C272, C293, E96, D41, D146, D226, D412, D449, D572, D638, D790, D1621, D1668, D4586, E96, E154.

B. Qualifications of Waterproofing Applicator:
1. Use applicator who is approved by the manufacturer.

2. Employ workers who have had experience in waterproofing of specified type on jobs of similar size and comparable structures. Have approved full-time superintendent or foreman supervise and direct waterproofing operations.
3. Inform the Engineer of proposed schedules and locations of waterproofing work.

C. Obtain waterproofing materials, sheet flashings, and protection course through one source from a single manufacturer.

D. Pre-installation Conference: Conduct conference at Project site. Review requirements for waterproofing, including surface preparation specified under other Sections, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to job site in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class, as applicable.

B. Store products in approved dry area with roll goods standing on ends. Protect from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Application of waterproofing to unprotected surfaces in wet weather or to surfaces on which ice, frost or dampness is visible is prohibited.
2. Unless otherwise approved, application of waterproofing unless ambient temperature is at least 40F and rising is prohibited.
3. Maintain rolls of material at a temperature of at least 50F for a period of not less than 24 hours prior to installation.

B. Provide ventilation in accordance with specified safety requirements.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Asphalt: ASTM D449, Type A.

B. Asphaltic Primer: ASTM D41

C. Glass Fabric: ASTM D1668, Type I or III.

D. Asphalt-Saturated Felt: ASTM D226, Type I.

E. Asphalt Cement (Asbestos-Free): ASTM D4586.

F. Waterproof Building Paper: ASTM C171, Regular.

G. Rubberized-Asphalt Sheet Membrane Waterproofing: Tough, pliable self-adhering waterproofing sheet of polyethylene film, coated on one side with a layer of adhesive-consistency rubberized asphalt, with the following additional requirements:

Characteristic	Value	Test Method
Thickness:		
a. Polyethylene film	4 mils	-
b. Rubberized asphalt	56 mils	-
c. Rubberized asphalt membrane total	60 mils	-
Permeance	0.1 perm	ASTM E96 Method B
Pliability, 180-degree bend over 1/4-inch mandrel at minus 30F	Unaffected	ASTM D146
Peel adhesion, 7 days dry plus 7 days at 120F plus 7 days dry or 7 days wet	5.0 pounds per inch, minimum	FS TT-S-230 Modified
Cycling over crack 15F, crack opened and closed from 0 inches to 1/4 inch	No effect 100 cycles	-
Puncture resistance, membrane	40 pounds minimum	ASTM E154
Tensile strength, membrane	250 pounds per square inch minimum	ASTM D412 Die C Modified

H. Asphaltic Mastic:

1. Solvent-base, containing synthetic rubber, asphalt and other components, suitable for troweling, as recommended by membrane manufacturer.
2. Dry-film requirements:
   a. Aging: No cracking, flowing, crazing, blistering, or delamination when subjected to 192 hours in oxygen bomb at 158F and 300-psi oxygen pressure in accordance with ASTM D572.
   b. Water permeability: 0.05-perm maximum when applied 1/32-inch thick over kraft paper and tested in accordance with ASTM E96.
   c. Stress: No cracking or delamination when 1/64-inch thick layer is applied on metal and bent five times 360 degrees at zero F on 1/16-inch mandrel.

I. Bonding and Joining Materials for Butyl Membrane:

1. Adhesive: For bonding butyl membrane to adjacent surfaces, as recommended by manufacturer of sheeting material.
2. Butyl compound: Self-vulcanizing for splicing joints in butyl membrane, as recommended by manufacturer.

3. Butyl gum tape: Unvulcanized butyl-gum rubber with polyethylene-backing material for splicing tape, as recommended by membrane manufacturer.
4. Flexible butyl-sheet rubber for flashings: As recommended by membrane manufacturer and as specified.

J. Protection Course Materials:
1. Concrete: Section 03300, class as shown.
2. Concrete block: Section 04220, ASTM C90, Type I.
3. Common brick: Section 04215, type and grade as shown
4. Concrete plank: Lightweight, reinforced-concrete plank, tongue-and-groove sides and ends, 16 inches wide, two inches thick, 10 feet long.
5. Protection board:
   a. Semi-flexible board, five ply or more, composed of asphaltic core sealed under heat and pressure between two liners of asphalt-saturated kraft paper or felt bonded to independent waterproofing during manufacturing process. Thickness as recommended by manufacturer.
   b. Extruded, rigid polystyrene-foam board, one-inch thick. Compressive strength 25-psi minimum, ASTM D1621; water absorption 0.1 percent, ASTM C272.
   c. Portland-cement mortar: Section 04050.

K. Epoxy-Injection Material for Repair of Leaks: Two-part epoxy-adhesive materials, containing 100-percent solids, having aromatic curing-agent surface M-phenylanediamine and meeting or exceeding the following minimum requirements:
1. Flexure strength: 400 psi in accordance with ASTM D790.
2. Tensile strength: 1,200 psi in accordance with ASTM D638.
3. Bond strength: ASTM C293 and as follows:
   a. Prepare concrete-beam test specimen in accordance with ASTM C192, using concrete mix design for 1-1/2 inch aggregate.
   b. Break concrete beam in accordance with ASTM C78.
   c. Bond broken beam using epoxy with bond-line thickness of 20 mils and cure for seven days at constant temperature of 65F.
   d. After curing, rebreak beam in accordance with ASTM C78.
   e. Attain specified values of flexure and tensile strength for repaired beam.
   f. Cores taken for testing in accordance with ASTM C42.

L. Protection-Board Adhesive: As recommended by the protection-board manufacturer.

2.02 WATERPROOFING SYSTEMS:

A. Fluid-Applied Membrane System:
1. Asphaltic primer.
2. Membranes: One of the following:
   a. Glass fabric.
   b. Asphalt-saturated felt.
3. Accessories:
   a. Asphaltic mastic.
   b. Asphalt cement.
   c. Butyl-gum tape.
   d. Boots.
   e. Iron clamps and bolts: Hot-dip, galvanized, ASTM A123, Grade 100; ASTM A153 Class A.

B. Rubberized-Asphalt Sheet Membrane System:
1. Asphaltic primer.

2. Rubberized-asphalt membrane.
3. Accessories:
   a. Asphaltic mastic.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Place membrane waterproofing after concrete has cured as specified in Section 03300 and surface is completely dry.

B. Keep surfaces thoroughly dry, immediately before and during application of waterproofing.

C. Should surface of the concrete become temporarily damp, dry surface.

D. Remove laitance, dust, dirt, projections, oil, grease and other matter by brooming, scraping, air-hosing or combination of such methods. Surface to be approved prior to application of waterproofing material.

E. Provide one-inch asphaltic mastic cants (fillets) in internal corners.

F. Prepare preconstructed protection of courses where shown in accordance with recommendations of membrane manufacturer. Fill holes and grooves.

G. Treat vertical surfaces with trowel coat of asphalt cement to fill pores and irregularities and level low areas to provide smooth surface for application of membrane waterproofing.

3.02 GENERAL INSTALLATION REQUIREMENTS:

A. Tightly fit waterproofing to structure without voids or kinks. Upon completion, allow no cuts, holes, pockets, bulges, wrinkles, folds or creases in surfaces of finished waterproofing; if such defects are present, repair by patching as specified. If waterproofing is damaged, punctured or in any way pervious and cannot be effectively patched or repaired, remove and replace to extent necessary to ensure that structure is waterproof.

B. Mop surfaces to be waterproofed in sections. Begin waterproofing at low point. Allow sufficient fabric for suitable overlap and anchorage at upper edge.

C. If leaks occur in areas where backfilling has not been placed, cut-out waterproofing and protection and patch as necessary to ensure watertight barrier. Where membrane is inaccessible, stop leaks with epoxy injection.

D. Cover horizontal surfaces of membrane waterproofing on which backfill is to be placed with portland-cement concrete of class and thickness shown and as specified in Section 03300.

E. Protect penetrations in membrane, such as pipes, conduits, piles, struts, walers and other braces. Provide sleeves, clamping rings or other approved devices at penetrations and install with counterflashing where shown and mastic tape where needed to ensure watertight joint.

F. Where shown in concrete floors and roof, fill electrical-bonding notches with asphalt cement finished flush with top of concrete.

3.03 FLUID APPLIED MEMBRANE SYSTEM:

A. General:

1. Approximately 24 hours before first mopping is applied, cover concrete surfaces to be waterproofed with one coat of asphaltic primer at minimum rate of one gallon per 100 square feet. Work primer well into surfaces to achieve uniform coating.
2. Completely cover concrete surfaces so that no concrete is left exposed. On fabric surfaces, apply mopping sufficiently heavy to conceal weave completely. For each mopping use not less than 4-1/2 gallons per 100 square feet of surface.
3. Regulate the work so that installed membrane receives final asphalt mopping before end of day. Thoroughly seal laps.
4. Before applying membrane on exterior of expansion and construction joints, lay strip of waterproof building paper twelve inches wide; extend six inches on each side of joint and secure to surface near edges using approved method.
5. Do not permit one layer of membrane to touch another layer, or concrete surface; separate each by mopped coat of hot asphalt.
6. At edges of membrane, insert membrane into reglets as shown and caulk with approved mixture of asphalt cement, or butyl-gum tape and necessary boots to prevent water intrusion between waterproofing and surface being waterproofed.
7. Where pipes, sleeves for pipes, or drains, penetrate surfaces to be waterproofed, provide synthetic-membrane flashings and two additional plies of membrane extending at least one-foot beyond edge of flashing, set in place with hot moppings of asphalt. Where flashing sleeves are not shown, flash membrane onto pipe or conduit with hot moppings of asphalt and secure with galvanized-iron clamps and bolts or by other approved methods.

B. Heating of Asphalt:

1. Heat asphalt to flow freely not exceeding 350F; stir frequently to avoid local overheating. Provide heating kettles of quality, number and capacity to service work adequately. Keep spare serviceable burners available at site for immediate replacement of malfunctioning burners. Keep kettleman in attendance during operation to ensure that maximum specified temperatures are not exceeded.
2. Employ kettle operators experienced in operating and maintaining type of equipment being used. Provide large metal pans at least one-inch deep under kettle to prevent drippings or fuel leaks from falling on prepared concrete or membraned surfaces. Ensure that each kettle is continuously equipped with calibrated thermometer.
3. Collect strippings from drums daily and remove from site. Set up kettles immediately adjacent to work in progress to reduce carrying distance of hot buckets.
4. Lower hot asphalt with extreme care to avoid endangering workmen in trench or excavation.

C. Two-Ply Work:

1. For first strip of membrane, use half-width; for second, use full-width, lapped full width of first strip.
2. For each succeeding strip, use full-width and overlap so that entire area has two layers of membrane except at joints. Lap joints two inches minimum, producing three plies at such overlaps.
3. Give entire surface final mopping of hot asphalt. When protective covering is shown, place covering on final mopping of asphalt while still hot.

D. Three-Ply Work:

1. Proceed as for two-ply work, except use 1/3-width for first strip; for second strip use 2/3-width; and for the third and succeeding strips use full-width. Overlap strips at least two inches, resulting in surface being completely covered by three plies, with four plies at overlaps.

E. More Than Three-Ply Work:
   1. Build in shingle fashion similar to three-ply work by adding as many plies as are shown. In joining membrane waterproofing to waterproofing in place, clean and heat in-place waterproofing before joining new waterproofing to that previously laid and overlap such joints one-foot minimum.
   2. At intersections of walls with horizontal surfaces, and at other locations, lap the greater number of plies of membrane over the other plies a minimum of one foot.
   3. Reinforce waterproofing at angles and expansion joints and at other locations where membrane may be subjected to unusual strain. Reinforce by means of two additional plies of saturated fabric and alternate moppings of asphalt. At angles between floor and wall provide reinforcing strips of sufficient width to extend six inches minimum on floor and four inches up wall. Extend strips at vertical corners five inches minimum on each side of corner.

F. Patching:
   1. Where the Engineer permits patching of defective waterproofing, extend first patching ply 12 inches minimum beyond outermost edge of defective portion.
   2. Extend second and each succeeding ply of patch three inches minimum beyond preceding ply.
   3. For patch area use at least as many new plies as specified for original membrane.

3.04 RUBBERIZED ASPHALT SHEET MEMBRANE SYSTEM:

A. Prime concrete surfaces as recommended by membrane manufacturer. Do not prime surfaces more than 36 hours prior to applying membrane. Allow primer to dry for one hour or until tack-free. Do not prime metal surfaces, but ensure that they are dry and free of grease, oil, dust, rust and other contaminants.

B. Apply membrane to clean primed surfaces. Lay membrane from low points or drains toward high points in shingle fashion. Overlap each strip 2-1/2 inches minimum and roll down firmly and completely.

C. Double-cover inside and outside corners with membrane by applying initial strip of minimum 12-inch width centered along axis of corner. Mortar inside corners; round outside corners.

D. Double-cover construction and control joints with membrane. Apply double thickness of membrane over sealed expansion joints.

E. Provide troweled bead of asphaltic mastic as recommended by membrane manufacturer to perimeter of membrane placed in each day's operation and to outside edges of membrane after the membrane is placed.

F. At areas around drains, posts and other protrusions, install double layer of membrane and coat liberally with asphaltic mastic.

G. Immediately before covering membrane, inspect carefully and patch holes, tears, misaligned or wrinkled seams and other discontinuities with membrane or mastic. Conduct 24-hour flood test with minimum two-inch head of water on horizontal areas. Repair leaks, using methods recommended by membrane manufacturer.

H. Place specified protection material on membrane within five days after application. Apply material in accordance with manufacturer's written instructions, as shown and as specified.

3.05 PROTECTION OF WATERPROOFED SURFACES:

A. Install protection courses as soon as practicable after waterproofing is placed. Do not place loads on exposed membrane waterproofing. Traffic on such exposed membrane waterproofing is prohibited.

B. Provide temporary protection as required pending installation of permanent protection.

C. Exercise care in placing protection courses against waterproofing so as not to break, tear, puncture or otherwise damage waterproofing.

D. Provide protection of waterproofing surfaces as shown and as specified.
   1. Concrete: Place concrete protection courses in accordance with the applicable requirements of Section 03300 and as shown.
   2. Concrete blocks and common brick: Lay concrete blocks and common brick in portland-cement mortar, as shown and in accordance with the related work sections
   3. Concrete plank: Erect concrete plank with tight tongue-and-groove joints as shown.
   4. Insulation board:
      a. Apply protection-board adhesive in accordance with the manufacturer's instructions.
      b. Fit boards carefully and neatly around pipes and projections and cover up entire surface of waterproofing.
   5. Protection board: Affix protection board to membrane surface by butting and taping or lapping and taping in accordance with manufacturer's written instructions and as approved.
   6. Backfill: At depths of 10 feet or more from top of structure, excluding reliefs, place layer of sand 12 inches thick over membrane as approved.

3.06 REPAIR OF LEAKS:

A. Repair areas of concrete which leak, including cracks and other defective areas, and areas where membrane is inaccessible by using injected waterproofing or by repair methods that provide an impervious and watertight envelope around affected areas. Use epoxy-injection method.
   1. Epoxy injection:
      a. Commence epoxy-injection work after embankment or other backfill and waterproofing membrane have been placed to full required height on structure and for minimum distance of thirty feet beyond extent of repair area.
      b. Install injection work from interior side of repair areas by port-to-port method. Port spacing: Approximately 1-1/2 times thickness of receiving concrete section.
      c. Preseal intermediate joints to prevent escape of epoxy and complete each repair area for its entire length before commencing work in another area.
      d. Before proceeding, sweep space in vicinity of joint or crack receiving epoxy and leave in a generally clean condition. Remove dirt, laitance and other loose material from areas receiving epoxy by means of compressed-air jet.
      e. At joints and cracks, complete in order floors, walls and ceilings. Proceed with work from port-to-port, beginning at one end of joint. Inject epoxy by means of small nozzle held tightly against port. Continue operation until material begins to exude from next port. Repeat operations from port-to-port until entire area has been treated in one continuous operation. Seal ports as necessary to prevent drips or runout.
      f. Remove ports and finish surface of joints and cracks flush with adjacent concrete surfaces leaving no indentations or evidence of port fittings. Point joint surfaces and remove excess material from adjacent surfaces as necessary to leave joint smooth.

g. Equip injection pumps with device to positively indicate failure to pump in proper proportions, as well as bypass valves and gauges compatible with pump.

h. The Engineer may take cores at any location for inspection and testing. When it is determined that epoxy material has not penetrated to sufficient depth or is otherwise unsatisfactory, costs of coring and testing are the responsibility of the Contractor; where tests demonstrate that work is not substandard, costs of coring and testing will be paid by the Authority.

i. When cores demonstrate that epoxy has penetrated less than 90 percent of crack volume within core, work will be considered defective. Repair defective work by refilling cracks at such locations to achieve at least 90-percent penetration.

END OF SECTION

SECTION 07 13 35

PVC MEMBRANE WATERPROOFING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Section Includes: This section specifies requirements for providing a permanent waterproofing system and associated construction drainage between the initial and the final linings.

B. Related Requirements:

1. Section 03 30 00 Cast-in-Place Concrete.
2. Section 05 50 00 Metal Fabrications.

C. Definitions:

1. Waterproofing: Geomembrane and geotextile installed around the entire circumference of the tunnel (invert and arch) between initial and final linings.
2. Geotextile: Geofabric providing groundwater drainage channel and protection of the geomembrane from sharp object projections of the initial lining.
3. Geomembrane: Synthetic membrane specifically formulated for waterproofing tunnel structure against groundwater pressure.
4. Invert drain: Temporary invert drain pipe
5. Water barrier: Water barriers installed around the entire circumference of tunnel where indicated.
6. Geo-drain filter fabric: Installed at weep holes where indicated.

1.03 PREINSTALLATION CONFERENCE

A. Prior to installation of waterproofing and associated work, meet at project site with waterproofing installer and installers of each component of associated work, including manufacturer's representatives and inspection personnel, to coordinate related requirements with waterproofing work.

B. Review material selections and procedures to be followed in performing work.

C. Perform a sample installation of each of the waterproofing materials.

D. Notify Engineer at least 48 hours before conducting meeting.

1.04 SUBMITTALS

A. Product Data: Submit complete catalogue cuts for each bentonite material used in the work, including manufacturer's installation instructions and data sheets indicating tensile strength, elongation, puncture resistance, resistance to hydrostatic head, pliability, permeability and water migration.

B. Shop Drawings:

1. Submit shop drawings, certified as reviewed and approved by the manufacturer, showing waterproofing membrane details at penetrations in the membrane (for pipes, conduits, etc.), corners of structures, ends of the membrane, joints in the structure, and interfaces with adjacent structures. Indicate joint or termination detail conditions, and conditions of interface with other materials. Indicate the sequence of installation of the materials.
2. Sheet layout of geomembrane detailing seams.
3. Details of seams, form bulkhead protection, attachment assembly for embedded lining items and other construction details.
4. Water barrier and geo-drain filter fabrics locations and details attachment.

C. Working drawings including sequence of installation and details of invert drain support.

D. Material Samples:

1. Geomembrane: One square foot.
2. Double welded seam: One foot long.
3. Geotextile: One square foot.
4. Membrane attachment system: Two.
5. Water barrier: One foot long, welded to geomembrane.
6. Geo-drain filter fabric: One square foot.

E. Manufacturer's Installation Recommendations:

1. Storage.
2. Handling.
3. Installation.
4. Seaming.
5. Attachment.
6. Testing.
7. Repair instructions.
8. Special instructions for corners and intersections.
9. Installation equipment.
10. Damage detection method.

F. Manufacturer and Installer Qualifications:

1. Evidence of manufacturer and installation qualifications.
2. Resume of lining installation supervisors.
3. Certification of compliance with the requirements of this specification.

G. Manufacturer's Certification: Submit written certification, signed by the manufacturer or authorized representative, per the following requirements:

1. Prior to the submittal of shop drawings, certify that the waterproofing materials are compatible with the groundwater and soil characteristics. Perform required groundwater and soil testing to confirm compatibility of materials at no additional cost to the Authority. A written report of

acceptability or required modifications to the bentonite mix to suit the subsurface conditions is to be submitted by the manufacturer.

2. Certify that the submitted shop drawings and installation instructions correctly describe the waterproofing system to be installed.

3. Certify that the materials furnished are compatible with each other.

4. Prior to installation, certify that the substrate is in an acceptable condition for membrane installation.

5. At completion of the installation, certify that the materials used in the work were in accordance with these Specifications, and that they were installed in accordance with the material manufacturer's installation instructions and recommendations.

H. Manufacturer's Field Report: Submit copies of project inspection reports confirming proper installation of waterproofing system.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with codes, laws and regulations of the authorities having jurisdiction (AHJ).

A. Reference Standards and Specifications: Provide membrane waterproofing in compliance with the following industry standards and as specified.

1. ASTM International (ASTM):
   a. ASTM A276, Standard Specification for Stainless Steel Bars and Shapes.
   b. ASTM D257, Standard Test Methods for DC Resistance or Conductance of Insulating Materials.
   c. ASTM D374, Standard Test Methods for Thickness of Solid Electrical Insulation.
   d. ASTM D638, Standard Test Method for Tensile Properties of Plastics.
   e. ASTM D746, Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
   f. ASTM D751, Standard Test Methods for Coated Fabrics.
   g. ASTM D1777, Standard Test Method for Thickness of Textile Materials.
   h. ASTM D2136, Standard Test Method for Coated Fabrics—Low-Temperature Bend Test.
   i. ASTM D3776, Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.
   j. ASTM D3787, Standard Test Method for Bursting Strength of Textiles—Constant-Rate-of-Traverse (CRT) Ball Burst Test.
   k. ASTM D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   l. ASTM D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   m. ASTM D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   n. ASTM D4716, Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.

2. National Fire Protection Association (NFPA):
   a. NFPA 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

B. Manufacturer's Qualifications:

1. Select a manufacturer who is regularly engaged in the production of similar geomembranes, geotextiles and water barriers.

C. Supervision and Training:

1. Have manufacturer's representative present during first 10 working days of installation.

2. Execute installation testing under direct supervision of an individual with recent, continuous and successful experience in the installation of tunnel membrane linings.

3. Provide personnel involved in lining installation and testing with training prior to beginning lining installation.

D. Membrane Protection:

1. Provide method and material to detect damage to geomembrane from final lining reinforcement placement.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver products to the jobsite in their original unopened containers clearly labeled with manufacturer's name, brand designation, referenced specification number, type and class, as applicable.

B. Store products in approved dry area, protected from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.07 FIELD CONDITIONS

A. Install waterproofing only after acceptance of initial lining.

B. Replace or repair sections of the waterproofing membrane determined to be defective in accordance with geomembrane seam testing or visual inspection.

1.08 WARRANTY

A. Special Installer's Warranty: Installer agrees to repair or replace acoustical joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Geotextile:

1. Non-woven, needle punched, 100 percent polypropylene geotextile of uniform thickness and surface texture.

2. Minimum Physical Properties:

Property	Testing Method	Minimum Specifications
Thickness (mils)	ASTM D1777	285
Unit Weight (oz../sq. yd.)	ASTM D3776	22
Grab Strength (lbs.)	ASTM D4632	285/340
Elongation (percent)	ASTM D4632	85
Trapezoidal Tear (lbs.)	ASTM D4533	135/155
Burst Strength (psi)	ASTM D3787	400
In-Plane Flow Rate(gpm/ft. width)	ASTM D4716	0.04
pH Range	—	2 to 13

B. Geomembrane:

1. General: Plasticized PVC (PVC-P) waterproofing membrane of uniform surface texture reinforced with woven reinforcing fabric of glass felt.

2. Physical Properties:

Property	Testing Method	Minimum Specifications
Thickness (inch)	ASTM D751	
Invert		0.118
Arch		0.079
Ultimate Tensile Strength(lbs./sq. in.)	ASTM D638	2000
Ultimate Elongation (percentage)	ASTM D638	
glass-felt-reinforced membrane		200
woven-fabric-reinforced membrane		25
Flammability	NFPA 701	Self Extinguishing
Dielectric Strength (volts/mil.)	ASTM D257	440 to 462
pH Range	—	2 to 13
Low Temperature Bend	ASTM D2136	Pass at minus 40F
Woven Reinforcing Fabric(oz./sq. yd.)		13 for woven-fabric-reinforced membrane

C. Invert Drain:

1. PVC pipe: Section 02625.

2. Support: Manufactured of PVC compatible materials.

D. Attachments: Manufactured of PVC compatible materials, with recess for metal washers and nail.

E. Water Barriers:

1. Base seal type water barrier with 6 rib minimum configuration, 1-1/2 inches minimum height, minimum 16 inches wide, manufactured from polyvinyl-chloride plastic compound, compatible with geomembrane.

2. Physical Properties:

Property	Testing Method	Minimum Specifications
Tensile Strength (lbs.)	ASTM D4632	100
Weight (oz./sq.yd.)	ASTM D3776	4.0
Water Flow Rate (gpm/sq. yd.)	ASTM D4491	160

F. Geo-Drain Filter Fabric:

1. BML Enterprises' B-Drain 60 or AKZO Industrial Systems Co.'s Enkadrain Type 9120 or approved equal.

2. Physical Properties:

Property	Testing Method	Minimum Specifications
Tensile Strength (lbs.)	ASTM D4632	100
Weight (oz./sq.yd.)	ASTM D3776	4.0
Water Flow Rate (gpm/sq. yd.)	ASTM D4491	160

G. Sponge Rubber: Neoprene, closed cell, minimum 1/4-inch thick, as approved by PVC membrane waterproofing manufacturer.

H. Neoprene Adhesive: As approved by PVC membrane waterproofing manufacturer.

I. Batten Plates: Stainless steel, ASTM A276.

J. Expansion Anchor Bolts: Section 05 50 00, hot-dip galvanized.

K. Non-shrink Grout: Section 03 30 00.

L. Auxiliary Materials:

1. Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.

PART 3 - EXECUTION

3.01 INITIAL LINING PREPARATION

A. Repair damaged or spelled areas having a depth of greater than one inch.

B. Patch or plug recesses left from temporary supports of greater than 1-1/2 inches in diameter or least dimension, installed in initial lining for construction purposes.

C. Where surface offsets between initial liners exceeds 2-1/2 inches, place cement mortar or bush hammer to provide for a smooth transition from one lining to the next.

D. Remove sharp points and protrusions.

3.02 INVERT DRAIN

A. Install as shown.

3.03 DRAINAGE FABRIC AND SYNTHETIC MEMBRANE

A. Installation Sequence:

1. Installation of geotextile with attachment assembly.
2. Welding of geomembrane of attachments.
3. Welding of seams.
4. Testing.
5. Installation of water barrier and filter fabric.
6. Testing.

B. Attachment of Geotextile Membrane:

1. Place attachment assemblies to achieve snug fit of geotextile membrane.
2. Provide minimum of two attachments for 10 square feet of waterproofing in the arch and one attachment per 10 square feet in the invert.
3. Provide additional attachments if required to provide support and fit to initial lining.

C. Provide sufficient scaffolding to allow inspection of installation.

D. Overlap materials minimum of three inches to form seams

E. Use radial seams in typical cross-sections unless otherwise approved.

F. Provide double seams unless single seams are approved.

G. Provide second layer of geomembrane welded over single seams. Second layer to completely cover single seams.

H. Where reinforcement is shown, use approved method to detect damage to geomembrane.

I. Provide attachment for reinforcement without penetration of the geomembrane.

J. Ensure flush contact between reinforcement spacers and geomembrane.

K. Provide minimum 1-1/2 inch clearance between items embedded in final lining and geomembrane, except grout pipes.

L. After the initial cast-in-place liner has cured, cap the drain pipe.

M. Provide attachment of water barriers at final cast-in-place liner construction joints at locations shown.

N. Provide attachment of geo-drain filter fabric at weep hole locations.

3.04 GEOMEMBRANE SEAM TESTING

A. General:

1. Perform tests in presence of Engineer
2. Perform tests as installation progresses. Before installation continues, repair and retest seams that fail tests.
3. Maintain written record for test results, repairs, and retesting.

B. Double Seams:

1. Test by applying internal air pressure between seams.
2. Test at 30 psi for 10 minutes.
3. Reject seam if pressure falls below 27 psi.

C. Single Seams (repairs and circular tunnel-structure interface only):

1. Perform visual inspection while running a rounded screwdriver or similar tool along the joint after the weld has cooled.

D. Water Barrier Welds: Spark test weld for capability of maintaining dielectric integrity at 2,500 volts minimum.

1. Directly behind each single weld between water barrier and membrane, insert one 18 gauge bare copper wire for testing.

2. Test the full length of the water barrier weld unless directed otherwise by the Engineer.

3. Document the welds tested and the number of defects repaired. Provide documentation to the Engineer.

E. Replace or repair sections of the membrane determined to be defective at no additional cost to the Authority.

END OF SECTION

SECTION 07210

BUILDING INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing building insulation.

B. Related Work Specified Elsewhere:
   1. Wood preservation treatment: Section 06075.
   2. Built-Up Roofing: Section 07515.
   3. Flashing and Sheet Metal: Section 07600.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Include manufacturer's material, handling, adhesive-mixing and application instructions for each type of product used in the work.
      b. Woodnailers, cant strips.
      c. Each tapered and flat roof insulation system.
         1) Show location and spacing of wood nailers and cants that are required for securing insulation and for back nailing of roofing felts. Show a complete description for he procedures for the installation of each phase of the system indicating the type of materials thicknesses, identity codes, sequence of laying insulation, special methods for cutting and fitting of insulation, and special precautions. The drawings shall be based on installation of the insulation in conjunction with the roofing system specified in Section 07515.
   2. Samples:
      a. Three of each type of the following materials used in the work:
         1) Insulation: 12- inch square units; pint container for loose fill.
         2) Adhesive: Pint containers.
         3) Fasteners: Six of each type.
         4) Asphalt: Pint containers.
         5) Vapor Barrier: 12 inches square.
         6) Cant strip: 12 inches long.
   3. Certification:
      a. Submit certification from manufacturer of insulation verifying that insulation applicator is approved by manufacturer, and has successfully performed at least three satisfactory insulation installations using methods and materials similar to those specified.
      b. Certification that materials furnished meet specified requirements and are compatible with each other.
   4. Test Reports:
      a. Submit flame spread and smoke developed ratings in accordance with ASTM E84.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: C516,C518, C549, C552, C665, C728, C1289, D41, D226, D312, D2626, D4586, E84.
3. FM: A/S4470, P7825.
4. FS: HH-I-1972/3.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to jobsite in their original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and rating as applicable.

B. Store products in approved dry area and protect from contact with soil, exposure to the elements and temperatures lower than 40F or higher than 150F. Keep products dry; store rolled goods standing on end.

C. Handle products so as to prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Application of roof insulation when ambient temperature is lower than 40F or when ice, frost or dampness are visible on the roof decks is prohibited.
2. Maintain temperature of 55F minimum in structure for 48 hours prior to, during and 48 hours after application of wall insulation.

B. Allowable Roof Loads:
1. During insulation application do not use equipment of weight which exceeds allowable roof load.

C. Coordinate insulation work with related roofing work.

PART 2 - PRODUCTS

2.01 ROOF INSULATION MATERIALS:

A. General: Use roof insulation materials acceptable to the roofing manufacturer. See related roofing specifications in other sections.

B. Insulation Board: One of the following materials for which installed thickness will produce overall average thermal resistance of R19.5, including decrease in thermal resistance value due to aging; and which is labeled and classified as a roof deck construction material by UL for use in Fire-Classified metal roof deck assemblies (TGKX), or by FM for use in Class-1 metal-roof-deck construction.
1. Composite polyisocyanurate (including polyurethane) board, ASTM C1289, Type III, factory faced with perlite insulation board on one side and asphalt-saturated felt on the other.
2. Perlite board, ASTM C728, Type 1; except with 35-psi compression resistance at five percent consolidation, and with integral factory-treatment designed to improve bond with built-up roofing membranes.

C. Tapered Insulation Board: Where roof slope through the use of tapered insulation is required, use approved insulation board as specified above, but factory fabricated so as to provide smooth drainage inclines (1/8-inch, 1/4-inch and 1/2-inch per 12 inches), as shown.

D. Asphalt Primer: ASTM D41.

E. Steep Asphalt: ASTM D312, Type III, or IV.

F. Asphalt-Saturated Felt: ASTM D226, Type I.

G. Asphalt Base Sheet: ASTM D2626.

H. Asphalt Cement (Asbestos-Free): ASTM D4586.

I. Asphalt for Glaze Coats: ASTM D312.

J. Adhesive: Manufacturer's standard.

K. Wood Nailers and Edges: Preservation treated per Section 06075.

L. Cant Strips and Tapered Edge Strips: Pre-fabricated from urethane or mineral aggregate board.

M. Nails and Tin Caps for Vapor Barriers: 11-gauge, annular-thread, 3/8-inch head, galvanized roofing nails and flat-disc galvanized-tin caps, 1-3/8 inch minimum diameter or galvanized combination nails and caps with one-inch heads.

N. Insulation Nails: Types standard with insulation manufacturer.

O. Clips and Fasteners: Types standard with metal-roof deck manufacturer; stainless steel or zinc coated, 18-gauge minimum.

2.02 WALL INSULATION MATERIALS:

A. Batt Insulation:
1. Fibrous flexible blankets faced with a reinforced foil-kraft facing vapro retarder.
2. Complies with ASTM C665, type III, Class B, Category 1.
3. Fire hazard classification rating of 25/50 or less, per ASTM E84.
4. Vapor Barrier Facing: Perms mazimum, 0.1 when tested in accordance with ASTM C518.
5. Thermal Resistance Minimum: R value of II except where indicated otherwise on the drawings. Thickness as indicated on drawings.

B. Loose-Fill Insulation:
1. Perlite: ASTM C549, Type IV (water-repellant and dust-control treated).
2. Vermiculite: ASTM C516, Type II (water-repellant treated), Premium Grade..

2.03 PERIMETER AND CAVITY WALL INSULATION:

A. Rigid Board types of cellular glass or polystyrene insulation with 15 psi compressive strength.
1. Cellar glass (Foamglass): ASTM C552. Minimum R value: 5.0 per inch of thickness
2. Polystyrene: ASTM C578, Minimum R value: 4.35 per inch of thickness with density of 1.0 lbs. Per cubic foot.

B. Adhesive and Fastenings: As recommended by the manufacturer.

C. Insulation inserts for concrete masonry units cores.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Prepare surfaces smooth, dry, clean, and free of projections, oil, grease, wax, rough mortar, debris and other substances that might prevent proper application of insulation.

B. Allow decks and wall surfaces to dry thoroughly before application of insulation. Test for dampness per manufacturer's recommendations.

C. Cut mortar joints flush with masonry walls. Remove fins and projections left after removal of concrete forms.

D. Back plaster walls with cement mortar, if necessary to obtain smooth surfaces.

3.02 APPLICATION OF ROOF INSULATION:

A. General Requirements for Application:
   1. Apply insulation in direct contact with roof deck or over vapor barrier, as shown. Keep roof-insulation materials dry before, during and after application. Place perlite side of composite insulation face up.
   2. Apply insulation to deck so that continuous longitudinal joints are parallel to short dimension of roof; stagger cross joints by starting alternate courses with half-size insulation boards. Keep insulation 1/2-inch clear of vertical surfaces.
   3. When using multiple layers of insulation, stagger the joints of each succeeding layer in both directions with respect to layer below. Embed succeeding layers firmly in solid mopping of steep asphalt.
   4. Mop sufficient area to provide complete embedment of one board at a time.
   5. Except for strip-mopping on metal decks, use 25 pounds minimum of asphalt per 100 square feet of roof deck for mopping each layer of insulation in place.
   6. Provide treated-wood nailers at edges of roofs and at intersections with vertical surfaces. Provide additional treated-wood nailers at necessary intervals for nailing insulation on non-nailable decks or for nailing roofing felt.
   7. Do not heat steep asphalt above 450F. Do not heat asphalt used for glaze coats above 400F. Apply steep asphalt at no less than 350F. Apply glaze coat at no less than 325F.

B. Application on Concrete Decks:
   1. Completely cover concrete decks with asphalt primer at minimum rate of one gallon per 100 square feet of roof surface.
   2. Vapor barrier:
      a. Provide vapor barrier consisting of two plies of asphalt-saturated felt with each ply lapped not less than 19 inches and mopped-in with steep asphalt. Vapor barrier, consisting of one layer of asphalt base sheets and weighing not less than 35 pounds minimum per 100 square feet, may be provided in lieu of two felt plies. Lap base sheets not less than four inches at sides and ends; solidly mop-in with steep asphalt.
      b. Mop-in vapor barriers at rate of 25 pounds minimum of steep asphalt per 100 square feet. Ensure that vapor barriers are free of wrinkles and buckles. Press air bubbles out to obtain proper adhesion between surfaces.
      c. At walls, edges and vertical projections, extend vapor barrier six inches to form lap to be wrapped around edge of insulation.
   3. Apply insulation as specified under general requirements for application.
   4. If roof slope exceeds one inch per foot, provide wood nailers for nailing insulation to roof deck. Use six nails minimum per eight square feet of insulation.

C. Application on Steel Decks:

1. Apply insulation so that joints occur on solid bearing surfaces only rather than over open ribs. Apply insulation of the indicated thickness and as required to achieve the roof slopes indicated.
2. Before insulation is installed, uniformly strip-coat high sections of steel deck with asphalt primer using 1/2-gallon minimum per 100 square feet of roof surface. Allow primer to dry.
3. Strip-mop high sections of deck using not less than 12 pounds of steep asphalt per 100 square feet of roof surface. Do not permit asphalt to flow into ribs or flutes of decking.
4. Place insulation while asphalt is still hot and fluid. When multiple layers of insulation are used, mop-in second layer and succeeding layers as specified under general requirements for application.
5. Fastening of insulation on steel decks:
   a. If roof slope exceeds one inch per foot, supplement asphalt moppings with mechanical fasteners. Where mechanical fastening is required, provide approved steel-deck, manufacturer's standard, nonpiercing, double-prong steel clips designed to fit into ribs of decking.
   b. Provide fastener of length necessary to accommodate thickness of insulation and with holding power 120 pounds minimum per fastener.
   c. Provide clips at the rate of 25 clips minimum per 100 square feet.

D. Cant Strips and Tapered Edge Strips:
1. Cant strips:
   a. Where shown or specified, provide 45-degree cant strips at intersections of roof with vertical surfaces extending above roof. Place cant strips on insulation and fit flush against vertical surfaces.
   b. Where possible, nail cant strips to adjoining surfaces. For installation against non-nailable materials, place cant strips in heavy mopping of steep asphalt or set in asphalt cement.
   c. Do not install projections, such as vent pipes and braces, through cant strips or within 10 inches from cant strips.
2. Tapered edge strips:
   a. Where shown or specified, provide tapered edge strips in right angle formed by junction of roof and wood nailing strips that extend above roof level. Fit strips flush against vertical surfaces of wood nailing strips.
   b. Where possible, nail edge strips to adjoining surfaces. Where installed against non-nailable materials, apply strips in heavy mopping of steep asphalt or set in asphalt cement.

E. Protection:
1. Cover each day's application of insulation, which cannot be roofed over, with at least one glaze coat of hot bitumen.
2. Protect open ends of each day's work with temporary water cut-offs; remove cut-offs when work is resumed.
3. Protect open spaces between insulation and parapets or other walls and spaces at curbs, scuttles, expansion joints and similar locations until permanent roofing and flashing is applied. Storing, walking, wheeling or trucking directly on insulation or on roofed surfaces is prohibited; provide smooth, clean board or plank walkways, runways and platforms as necessary.
4. Limit storage loads on platforms and wheeling loads to 40 psf uniformly distributed. Limit size and weight of mechanical equipment used for insulation work so that deflection of roof deck under its use does not exceed 1/240 of deck span.

3.03 APPLICATION OF MASONRY-CELL WALL INSULATION:

A. Follow manufacturer's recommended installation practices.

B. Pour loose-fill insulation into cells of concrete masonry units as masonry work progresses. Use approved procedures to ensure complete filling of cells.

C. Minimize free fall impact and dust formation.

3.04 APPLICATION OF BATT INSULATION:

A. The vapor barrier facing shall face toward the warm-in-winter side of the space.

B. Lay batts on top of soffit tightly butted together.

C. Attach wall mounted batts with, mechanical fasteners as required for permanent installation.

3.05 APPLICATION OF PERIMETER CAVITY WALL INSULATION:

A. Secure vertical insulation with mechanical fasteners sufficient to permanently retain all insulation in place during subsequent construction operations.

B. Fitted with tight butt joints with openings for penetrations nearly cut for tight fit.

C. Placed just prior to subsequent construction operations to prevent damage of insulation left exposed. Coordinate with masonry work. Prevent damage during placement of fill and compaction or concrete against insulation.

D. Place insulation in concrete masonry unit cores at plant prior to job site delivery.

3.06 CLEAN-UP:

A. Clean up rubbish and debris caused by this work and remove from site.

B. Remove drippings of asphalt and adhesives in exposed places on brick, concrete, steel, metal or other surfaces.

END OF SECTION

SECTION 07523

ETHYLENE-PROPYLENE-DIENE-MONOMER (EPDM) ROOFING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Adhered ethylene-propylene-diene-monomer (EPDM) roofing system.
2. Vapor retarder.
3. Roof insulation.
4. Expansion joints.
5. Walkway pads.

B. Related Requirements:

1. Section 06105 "Miscellaneous Rough Carpentry" for wood nailers, curbs, and blocking.
2. Section 07015 "Preparation for Re-Roofing."
3. Section 07600 "Flashing and Sheet Metal" for metal roof flashings and counter flashings.
4. Section 07900 "Joint Sealants" for joint sealants, joint fillers, and joint preparation.

1.03 DEFINITIONS

A. Roofing Terminology: Definitions in ASTM D1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" apply to work of this Section.

1.04 PREINSTALLATION MEETINGS

A. Preinstallation Roofing Conference: Conduct conference at Project site insert list of conference participants as required in Section 01312 "Project Meetings."

1. Meet with Authority’s Representative, Architect, Authority’s insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.

5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

1.05 SUBMITTALS

A. Product Data: For each type of product. Include manufacturer's technical data, indicating membrane materials, base flashing materials, insulation, cover board, fasteners and adhesives, accessories and details, preparation instructions and recommendations, storage and handling requirements and recommendations.

B. Sustainable Design Submittals:

1. LEED Submittals ;
   a. Product Test Reports for Credit SS 7.2: For roof materials, documentation indicating that roof materials comply with Solar Reflectance Index requirement.
   b. Product Data for Credit IEQ 4.1: For adhesives and sealants used inside the weatherproofing system, documentation including printed statement of VOC content.
   c. Product data using LEED Criteria Worksheet for each type. Refer to Section 01 81 13 "Sustainable Design Requirements" for project requirements.

C. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work, including:

1. Base flashings and membrane terminations.
2. Tapered insulation, including slopes.
3. Roof plan showing orientation of roof deck and orientation of roofing and fastening spacings and patterns for mechanically fastened roofing.
4. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.

D. Samples for Verification: For the following products:

1. Sheet roofing, of color required.
2. Roof Insulation.
3. Insulation and roof cover fasteners of each type, length and finish.
4. Walkway pads or rolls, of color required.

E. Qualification Data: For Installer and manufacturer.

F. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.

1. Submit evidence of complying with performance requirements.

G. Product Test Reports: For components of roofing system, tests performed by manufacturer and witnessed by a qualified testing agency.

H. Research/Evaluation Reports: For components of roofing system, from ICC-ES.

I. Field quality-control reports.

J. Sample Warranties: For manufacturer's special warranties.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

1.07 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with codes, laws and regulations of the authorities having jurisdiction (AHJ).

B. Reference Standards and Specifications: Provide EPDM roofing in compliance with the following industry standards and as specified.

1. ASTM International (ASTM):
   a. ASTM C1177, "Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing."
   b. ASTM C1289, "Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board."
   c. ASTM D4397, "Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications."
   d. ASTM D5957, "Standard Guide for Flood Testing Horizontal Waterproofing Installations, containment assemblies."
   e. ASTM D312, "Standard Specification for Asphalt Used in Roofing."
   f. ASTM D3746, "Standard Test Method for Impact Resistance of Bituminous Roofing Systems."
   g. ASTM D41, "Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing."
   h. ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method."
   i. ASTM D4272, "Standard Test Method for Total Energy Impact of Plastic Films by Dart Drop."
   j. ASTM D4637, "Standard Specification for EPDM Sheet Used In Single-Ply Roof Membrane."
   k. ASTM E1980, "Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces."
   l. ASTM G152, "Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials."
   m. ASTM G154, "Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials."
   n. ASTM G155, "Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials."
2. FM Global (FM):
   a. FM Global 4450, "FM Approval Standard 4450, Class 1 Insulated Steel Deck Roofs."
   b. FM Global 4470, "FM Approval Standard 4470, the Approval Standard for Single Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof and Liquid Applied Roof Assemblies for use in Class I and Noncombustible Roof Deck Construction."
3. Polyisocyanurate Insulation Manufacturers Association (PIMA):
   a. PIMA 101, "Roof Insulation Specimen Conditioning Procedure (RIC/TIMA 281-1)."

C. Manufacturer Qualifications: A qualified manufacturer that is UL listed and FM Global approved for roofing system identical to that used for this Project.

D. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.

1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.

1.09 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

B. Temporary Roofing: When adverse job conditions or weather conditions prevent permanent roofing and associated work from being installed in accordance with requirements, and it is determined by Contractor that roofing cannot be delayed because of need for job progress or protection of other work, proceed with installation of temporary roofing, per requirements of the roofing manufacturer.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes membrane roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, and other components of roofing system.

2. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Source Limitations: Obtain components including roof insulation, fasteners**,** and roofing accessories or roofing system from same manufacturer as membrane roofing or manufacturer approved by membrane roofing manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. General Performance: Installed roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing and base flashings shall remain watertight.

1. Accelerated Weathering: Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G152, ASTM G154, or ASTM G155.
2. Impact Resistance: Roofing system shall resist impact damage when tested according to ASTM D3746 or ASTM D4272.

B. Material Compatibility: Roofing materials shall be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roofing manufacturer based on testing and field experience.

C. FM Global Listing: Roofing, base flashings, and component materials shall comply with requirements in FM Global 4450 or FM Global 4470 as part of a roofing system, and shall be listed in FM Global's "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

1. Fire/Windstorm Classification: Class 1A-60 or as dictated by loads shown on the Drawings.
2. Hail-Resistance Rating: MH.

D. Solar Reflectance Index: Not less than 78 when calculated according to ASTM E1980, based on testing identical products by a qualified testing agency.

E. Energy Star Listing: Roofing system shall be listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low -slope roof products.

F. Fire-Resistance Ratings: Comply with fire-resistance-rated assembly designs indicated. Identify products with appropriate markings of applicable testing agency.

2.03 EPDM ROOFING

A. EPDM Membrane: ASTM D4637, Type II, scrim or fabric internally reinforced, uniform, flexible EPDM sheet.

1. Thickness: 90 mils, nominal.
2. Exposed Face Color: White on black.

B. Basis of Design: Firestone Building Products, "ECOWHITE Platinum EPDM", fully adhered.

C. Seaming Materials: As recommended by roofing system manufacturer.

D. Battens: As recommended by roofing system manufacturer.

E. Reglets: As recommended by roofing system manufacturer.

F. Adhesive Materials:

1. Surface Conditioner: As recommended by roofing system manufacturer.
2. Membrane Adhesives: As recommended by roofing system manufacturer.

3. Insulation Adhesive: As recommended by roofing system manufacturer.

4. Thinner and Cleaner: As recommended by roofing system manufacturer,

G. Flashings and Counter Flashings: As recommended by roofing system manufacturer.

H. Stack Boots: Flexible boot and collar for pipe stacks through membrane as recommended by roofing system manufacturer.

I. Expansion Joint Material: As recommended by roofing system manufacturer.

2.04 AUXILIARY ROOFING MATERIALS

A. General: General:

1. Auxiliary membrane roofing materials shall be recommended by the roofing system manufacturer and be for intended use and compatible with membrane roofing.

2. Liquid-type auxiliary materials, adhesives and sealants, shall comply with VOC limits according to 40 CFR 59 and authorities having jurisdiction (AHJ). See Section 01 81 13 “Sustainable Design Requirements” for project requirements.

B. Sheet Flashing: 60-mil- thick EPDM, partially cured or cured, according to application.

C. Protection Sheet: Epichlorohydrin or neoprene nonreinforced flexible sheet, 55- to 60-mil- thick, recommended by EPDM manufacturer for resistance to hydrocarbons, non-aromatic solvents, grease, and oil.

D. Bonding Adhesive: Manufacturer's standard.

E. Seaming Material: Manufacturer's standard, synthetic-rubber polymer primer and 3-inch-wide minimum, butyl splice tape with release film.

F. Lap Sealant: Manufacturer's standard, single-component sealant, colored to match membrane roofing.

G. Water Cutoff Mastic: Manufacturer's standard butyl mastic sealant.

H. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch thick; with anchors.

I. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick, prepunched.

J. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening membrane to substrate, and acceptable to roofing system manufacturer.

K. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, molded pipe boot flashings, preformed inside and outside corner sheet flashings, reinforced EPDM securement strips, T-joint covers, in-seam sealants, termination reglets, cover strips, and other accessories.

1. Provide white flashing accessories for white EPDM membrane roofing.

2.05 SUBSTRATE BOARDS

A. Substrate Board: ASTM C1177, glass-mat, water-resistant gypsum substrate,1/2 inch thick.

B. Fasteners:

1. Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening substrate panel to roof deck.

2. No fasteners shall be exposed to view on underside of walkway bridge roof deck.

2.06 VAPOR RETARDER

A. Polyethylene Film: ASTM D 4397, 6 mils thick, minimum, with maximum permeance rating of 0.13 perm; as recommended by roofing system manufacturer.

1. Adhesive: Manufacturer's standard lap adhesive, FM Global approved for vapor-retarder application.

2.07 ROOF INSULATION

A. General: Preformed roof insulation boards manufactured or approved by EPDM roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Global-approved roof insulation.

B. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 1, Grade 2 felt or glass-fiber mat facer on both major surfaces.

1. Thermal Resistance: Provide insulation with 5-year conditioned R-value of minimum 6.00 per inch as determined by ASTM C518 at 75 degrees F mean temperature with specimens conditioned in accordance with PIMA Bulletin No. 101 and RIC/TIMA Bulletin No. 281-1. Provide insulation with a minimum R-value of 35.0 unless a higher R-value is indicated on the drawings. R-value and thickness for tapered insulation shall be an average R-value and thickness.

C. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches unless otherwise indicated.

D. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.08 INSULATION ACCESSORIES

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with roofing.

B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.

C. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer as follows:

1. Full-spread spray-applied, low-rise, two-component urethane adhesive.

D. Cover Board: ASTM C1177, glass-mat, water-resistant gypsum substrate, 5/8 inch thick, factory primed.

2.09 ASPHALT MATERIALS

A. Roofing Asphalt: ASTM D312, Type III or Type IV.

B. Asphalt Primer: ASTM D41.

2.10 WALKWAYS

A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, solid-rubber, slip-resisting, surface-textured walkway pads, minimum 2 ft X 2 ft, approximately 3/16 inchthick, fully adhered, and acceptable to roofing system manufacturer to form continuous path from roof access points leading up to and around all rooftop mechanical equipment.

1. Colors and Textures: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work:

1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
3. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Section 05310 "Steel Decking."
4. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
5. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D4263.
6. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

3.03 ROOFING INSTALLATION, GENERAL

A. Install roofing system according to roofing system manufacturer's written instructions.

B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.

C. Install roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing roofing system.

3.04 SUBSTRATE BOARD INSTALLATION

A. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.

1. Fasten substrate board to top flanges of steel deck according to recommendations in FM Global's "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.

2. Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to roofing system manufacturers' written instructions.

3.05 VAPOR-RETARDER INSTALLATION

A. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inchesand 6 inches, respectively. Continuously seal side and end laps with tape.

B. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into roofing system.

3.06 INSULATION INSTALLATION

A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.

B. Comply with roofing system and insulation manufacturer's written instructions for installing roof insulation.

C. Install tapered insulation under area of roofing to conform to slopes indicated.

D. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inchesin each direction.

1. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.

E. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.

F. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch with insulation.

1. Cut and fit insulation within 1/4 inchof nailers, projections, and penetrations.

G. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:

1. Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

H. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten first layer of insulation according to requirements in FM Global's "RoofNav" for specified Windstorm Resistance Classification.

2. Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

I. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inchesin each direction. Loosely butt cover boards together and fasten to roof deck.

1. Fasten cover boards according to requirements in FM Global's "RoofNav" for specified Windstorm Resistance Classification.

2. Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.

3.07 ADHERED MEMBRANE ROOFING INSTALLATION

A. Adhere roofing over area to receive roofing according to membrane roofing system manufacturer's written instructions. Unroll membrane roofing and allow to relax before installing.

B. Start installation of roofing in presence of roofing system manufacturer's technical personnel.

C. Accurately align roofing, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

D. Bonding Adhesive: Apply to substrate and underside of roofing at rate required by manufacturer, and allow to partially dry before installing roofing. Do not apply to splice area of roofing.

E. Hot Roofing Asphalt: Apply a solid mopping of hot roofing asphalt to substrate at temperature and rate required by manufacturer, and install fabric-backed roofing. Do not apply to splice area of roofing.

F. Fabric-Backed Membrane Adhesive: Apply to substrate at rate required by manufacturer, and install fabric-backed roofing.

G. In addition to adhering, mechanically fasten roofing securely at terminations, penetrations, and perimeters.

H. Apply roofing with side laps shingled with slope of roof deck where possible.

I. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of roofing terminations.

J. Repair tears, voids, and lapped seams in roofing that do not comply with requirements.

K. Spread sealant or mastic bed over deck-drain flange at roof drains, and securely seal membrane roofing in place with clamping ring.

L. Adhere protection sheet over membrane roofing at locations indicated.

3.08 FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories, and adhere to substrates according to roofing system manufacturer's written instructions.

B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

D. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.

E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.09 WALKWAY INSTALLATION

A. Flexible Walkways:

1. Install walkway products in locations indicated. Adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to inspect substrate conditions, surface preparation, membrane application, flashings, protection, and drainage components, and to furnish reports to Architect.

B. Leak Testing: Perform roofing leak testing by electronic testing methods in accordance with the roofing system assembly manufacturer's recommendations, after completing roofing and flashing but before overlying construction is placed.

C. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

D. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.

E. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.11 PROTECTING AND CLEANING

A. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates, and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

SECTION 07600

FLASHING AND SHEET METAL

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing miscellaneous-waterproofing sheet metal including metal flashings, copings, exposed trim, fasciae, gravel stops, reglets, scuppers, gutters and downspouts, conductor heads, splash pans, drip edges, roof and roof-to-wall expansion joint covers, shower pans, overhead piping safety pans, metal accessories, gutter screens, strainers, red-rosin paper, solder, and related nailing strips and miscellaneous wood supports.

B. Related Work Specified Elsewhere:
1. Brick Masonry: Section 04215.
2. Concrete Unit Masonry: Section 04220
3. Rough Carpentry: Section 06100.
4. Seals and Sealants: Section 07900.
5. Roof Accessories: Section 07730.
6. Sheetmetal Roofing Systems: Section 07411.
7. Built-up Roofing: Section 07515.

1.02 PERFORMANCE REQUIREMENTS:

A. General: Install sheet metal flashing and trim to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing.

B. Fabricate and install flashings at roof edges to comply with recommendations of FM Loss Prevention Data Sheet 1-49 for the following wind zone:
1. Wind Zone 3: Wind pressures of 46 to 104 psf.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data including manufacturer's material and finish data, installation instructions, and general recommendations for each specified flashing material and fabricated product.
2. Shop Drawings:
   a. Show both shop-fabricated and site-fabricated work, indicating where each item is fabricated. Include complete details of joints, supports and fasteners, in accordance with SMACNA Architectural Sheet Metal Manual standard details where applicable.
   b. Show dimensions and locations of wood nailing strips, miscellaneous wood supports and details of installation.
   c. Fabricated Masonry Flashing: Detail corner units, end-dam units, and other special applications.
3. Samples: Three of each type of the following materials used in the work:
   a. Stainless steel: 12 inches square.
   b. Lead-coated copper: 12 inches square.
   c. Bituminous paint: Pint containers.
   d. Aluminum coping: 12-inch by 12-inch corner section.
   e. Stainless steel coping: 12-inch by 12-inch corner section.

f. Reglets: 12-inch strips.
g. Expansion-joint cover: 12-inch strips.
h. Downspout and gutter: 12-inch length with anchor strap.
i. Copper-Laminated Flashing: 12 inches square.
j. Coil-coated galvanized steel: 12 inches square.
k. Copper: 12 inches square.
l. Metal accessories.

B. Certification.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. SMACNA: Architectural Sheet Metal Manual.
3. FS: QQ-L-201, UU-B-790.
4. AAMA: 606.1.
5. NRCA: Roofing and Waterproofing Manual.
6. ASTM: A167, A755, B32, B101, B209, B221, B370.
7. UL: 580 for Class 90 wind-uplift resistance.
8. FM: Loss Prevention Data Sheet 1-49.
9. Copper Development Association: Copper in Architecture Handbook.

B. Installer Qualifications: Engage an experienced Installer who has completed sheet metal flashing and trim work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

C. Coordinate Work of this Section with interfacing and adjoining Work for proper sequencing of each installation. Ensure best possible weather resistance, durability of Work, and protection of materials and finishes.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to jobsite in original unopened containers clearly marked with manufacturer's name and brand designation, reference specification number, type and class as applicable.

B. Store products in approved dry area and protect from contact with soil and exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Stainless Steel:
1. Through-wall flashing (mechanically keyed) sheets: ASTM A167, Type 304, soft annealed, minimum thickness 0.012 inch.
2. Fascia, exposed trims, reglets, roof drain flashings, base flashings, counterflashings, flashing receivers, valley flashings, drip edges, eave flashings, equipment support flashings, roof penetration flashings, roof expansion joint covers, scuppers: ASTM A167, Type 304, hard tempered, minimum thickness 0.0187 inch, unless otherwise shown or indicated.

3. Copings, gravel stops, and roof-to-wall expansion joint covers: ASTM A167, Type 304, hard tempered, minimum thickness 0.025 inch, unless otherwise shown or indicated.
    a. Backing or stiffeners required to prevent oil-canning and waviness.
    b. Finish: No. 2D.

B. Copper Sheet and Strips: ASTM B370; temper H00, cold-rolled except where temper 060 is required for forming:
1. Shower pans: Not less than 16-ounces/square foot, unless otherwise shown.
2. Concealed copper-laminated flashing:
    a. Manufacturer's standard laminated flashing consisting of 7-oz./sq. ft.sheet copper bonded with asphalt between 2 layers of glass-fiber cloth. Use only where flashing is fully concealed in masonry.

C. Lead-Coated Copper:
1. ASTM B101, cold-rolled copper sheet with temper O60 (soft) for flashing, temper H00 or H01 for other uses as appropriate, sheet weight and lead coating weight as specified below:
    a. Gutters with girth up to 20 inches, downspouts, conductor heads, reglets, base flashings, counterflashings, flashing receivers, valley flashings, drip edges, eave flashings, equipment support flashings, roof drain flashings, roof penetration flashings, roof expansion joint covers, roof-to-wall expansion joint covers, and splash pans: Copper sheet weighing not less than 16 ounces/square foot.
    b. Scuppers: Copper sheet weighing not less than 20 ounces/square foot.
    c. Gutters with girth larger than 20 inches and overhead piping safety pans: Copper sheet weighing not less than 24 ounces/square foot.
    d. Both sides of copper sheet coated with lead weighing not less than 12 nor more than 15 pounds/100 square feet, unless otherwise indicated.

D. Coil-Coated Galvanized Steel Sheet:
1. Zinc-coated, commercial quality steel sheet with thickness as specified below conforming to ASTM A755, G90 coating designation, coil coated with high-performance fluoropolymer coating of not less than 1 mil thick (0.2 mil primer and 0.8 mil fluoropolymer) each side, unless otherwise specified.
2. Counter flashings and flashings receivers: Minimum thickness of steel sheet 0.0217 inch, unless otherwise shown or indicated.
3. Fasciae, trims, drip edges, eave flashings, base flashings, valley flashings, and equipment support flashings: Minimum thickness of steel sheet 0.0276 inch, unless otherwise shown or indicated.
    a. Backing or stiffeners for fasciae and trims required to prevent oil-canning and waviness.

E. Aluminum:
1. Extruded anodized fasciae, exposed trims, copings and gravel stops: ASTM B221, Alloy 6063-T52, minimum thickness 0.125 inch.
2. Alloy sheet anodized scuppers, roof expansion joint covers, and roof-to-wall expansion joint covers: ASTM B209, Alloy 5005-H14, minimum thickness 0.050 inch.
3. Alloy sheet anodized drip edges, eave flashings, base flashings, counterflashings, and flashing receivers: ASTM B209, Alloy 5005-H14, minimum thickness 0.040 inch.
4. Finish: Class I color anodized finish with anodic layer thicker than 0.7 mil, dark bronze color, per AAMA 606.1, Guide Specifications and Inspection Methods for Integral Color Anodic Finishes for Architectural Aluminum.

F. Lead:
1. Flashing for plumbing vents:
a. Sheet lead, FS QQ-L-201, minimum 2-1/2 pounds per square foot.

G. Miscellaneous Items:
1. Red-rosin paper:
a. FS UU-B-790, Type I, Style 1b, 5 lb/sq., sized building paper.
2. Vinyl tape: As recommended by the metal product manufacturer as a dissimilar metal separator.
3. Wood blocking: Section 06100.
4. Bituminous Paint: As recommended by the manufacturer as a dissimilar metal separator.
5. Solder: ASTM B32, with flux-core; of the following solder alloys. Use another alloy if it is demonstrated to the Engineer that better results, including visual as applicable, can be achieved on the particular metals being joined.
a. For stainless steel: Tin/silver solder, Alloy Grade Sn96, with acid flux of type recommended by stainless steel manufacturer.
b. For copper: 50-50 tin/lead solder, Alloy Grade Sn50, with rosin flux.For lead-coated copper: 60-40 tin/lead solder, Alloy Grade Sn60, with rosin flux.
6. Sealant:
a. Elastomeric: Section 07900.
b. Epoxy Seam Sealer: Two-part, non-corrosive, aluminum seam-cementing compound as recommended by aluminum manufacturer for exterior and interior non-moving joints including riveted joints.
c. Mastic Sealant: Polyisobutylene, nonhardening, nonskinning, nondrying, nonmigrating sealant.
7. Metal Accessories and Fasteners: Provide sheet metal clips, straps, anchoring devices, and similar accessory units as required for installation of Work, matching, matching finish of exposed heads, or compatible with material being installed as approved; noncorrosive; size and thickness required for performance per approved samples.
8. Gutter Screen: 1/4-inch non-corrosive hardware cloth installed in sheet metal frames.
9. Adhesives: Type recommended by flashing sheetmetal manufacturer for waterproof and weather-resistant seaming and adhesive application of flashing sheetmetal.
10. Roofing Cement: ASTM D4586, Type I, asbestos free, asphalt based.
11. Asphalt Mastic for under flashing receivers and counterflashing and paint on lap seams and base flashing: SSPC-Paint 12, solvent-type mastic, nominally free of sulfur and containing no asbestos fibers, compounded for 15-mil dry-film thickness per coat.

2.02 FABRICATION, GENERAL:

A. Sheet Metal Fabrication Standard: Fabricate sheet metal flashing and trim to comply with recommendations of SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of the item indicated.

B. Comply with details shown to fabricate sheet metal flashing and trim that fit substrates and result in waterproof and weather-resistant performance once installed. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

C. Form exposed sheet metal Work that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems.

D. Expansion Provisions: Space movement joints at maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions in the Work cannot be used or would not be sufficiently weatherproof and waterproof, form expansion joints or intermeshing hooked flanges, not less than one-inch deep, filled with mastic sealant (concealed within the joints).

E. Fabricate nonmoving joints with flat-lock seams. For tin edges to be seamed, form seams and solder. For aluminum to be seamed, form seams and seal with epoxy seam sealer and rivet joints for additional strength as approved.

F. Sealed joints: Form movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.

G. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of sheet metal exposed to public view.

H. Fabricate cleats and attachment devices from same material as sheet metal component being anchored or from compatible, noncorrosive metal recommended by sheet metal manufacturer.
1. Size: As recommended by SMACNA manual or sheet metal manufacturer for application but never less than thickness of metal being secured.

2.03 SHEETMETAL FABRICATIONS:

A. Downspout: Plain, rectangular, lead-coated copper in accordance with SMACNA Architectural Sheet Metal Manual standards, unless otherwise shown.

B. Gutters: Lead-coated copper in accordance with SMACNA standards.

C. Gutter Screen: Fabricate screen and frame of approved material

D. Reglets:
1. Stainless steel or lead-coated copper, matching flashing material, closed-slot, friction-type.

E. Roof and Wall-to-Roof Expansion Joint Covers:
1. Combination of neoprene and lead-coated copper or stainless steel, with the following additional requirements:
a. Cover with neoprene bonded to metal edgings by means of neoprene-based adhesive comprising primer and vulcanizing cement to produce high-strength bond.
b. For neoprene part of cover, cured neoprene sheet, tensile strength 1,500-psi minimum, elongation 250-percent minimum, bonded to metal with peel-pull value of 25 pounds per inch minimum at right angles; thickness and width as shown.
c. Edgings of metal cover, four inches wide, perforated with holes four inches on centers minimum.

F. Coping and Gravel Stops:
1. Extruded aluminum or stainless steel, assemblies tested for wind-uplift resistance in accordance with UL 580 for Class 90-uplift resistance, or greater as required by jurisdictional authority, with testing performed by testing agency acceptable to the Engineer.

a. Size: 10-foot long sections, with factory-fabricated corners and intersections, formed with no visible fasteners.
b. Movement joint design: Incorporate a waterproof seal using an internal weep system and rubber or vinyl seals into the non-welded joints.
c. Fasteners and clips: As standard with the manufacturer for required wind-uplift resistance. Where exposed, finish to match the metal finish.

G. Flashing for Plumbing Vents:
1. Lead, sized to extend at least four inches horizontally on roof around pipe, over pipe, and one-inch inside pipe.

H. Strainer:
1. Stainless-steel ,12-gauge wires spaced not greater than 1/2-inch apart, as shown and as approved.

I. Miscellaneous-waterproofing sheetmetal flashings, fasciae, trims, drip edges, scuppers, conductor heads, shower pans, splash pans, and overhead piping safety pans:
1. Fabricated from material as previously specified, sized as shown and as approved.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Clean dirt, debris, grease, oil and other foreign substances from surfaces that are to receive metalwork. Coordinate with work of other Sections: 04215, 04220, 07411, and 07730.

3.02 INSTALLATION:

A. Coordinate flashing and sheet metal with the work of other trades. Shop-fabricate the work whenever possible. Provide for expansion and contraction of sheet metal.

B. Install the work of this Section in accordance with the NRCA Roofing and Waterproofing Manual, performance requirements, manufacturers' instructions and SMACNA's Architectural Sheet Metal Manual. Anchor units securely in place by methods indicated and conceal fasteners where possible. Set units true to line and level with exposed edges folded back to form hems. Install exposed sheetmetal without excessive oil canning, buckling and tool marks. Verify shapes and dimensions of surfaces to be covered prior to fabrication and trim to fit substrates. Install work with laps, joints and seams that will be permanently watertight and weatherproof. Provide for thermal expansion of metal units. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weatherproof and waterproof, form expansion joints of intermeshing hooked flanges not less than one-inch deep and fill with mastic sealant concealed within joints. Form nonexpansion joints in metal to accommodate elastomeric sealant to comply with SMACNA standards. Fill joint with sealant and form metal to completely conceal sealant. Use joint adhesive for non-moving joints specified not to be soldered. Fabricate non-moving seams in sheetmetal with flat-lock seams, except fabricate non-moving seams in aluminum with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints as approved for additional strength.. Tin edges to be seamed, form seams and solder.

C. Perform cutting, drilling and other operations in connection with sheet metal work to accommodate work of other trades. Provide accessories as recommended by SMACNA Architectural Sheet Metal Manual.

D. Where sheet metal abuts or interfaces with adjacent materials, join as shown on approved shop drawings. Isolate dissimilar metals by use of compatible coatings or other approved methods. Apply red-rosin paper backing for sheet metal applied to any surface to permit movement caused by expansion or to prevent galvanic action.

E. Soldering:
1. Clean surfaces to be soldered to remove oils and foreign matter. Brush liberal amount of flux on seams, solder immediately, neutralize acid and clean.
2. Solder slowly, thoroughly heating seam and completely sweating solder through full width of seam. Use ample solder for full width along seams.
3. Do not solder aluminum and coil-coated galvanized steel sheet. Pre-tinning is not required for lead and lead-coated copper. Do not use torches for soldering, heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.

F. Seams:
1. Flat lock: 3/4-inch wide, minimum.
2. Solder lap: One-inch wide, minimum
3. Unsoldered plain lap: Three-inches wide, minimum.
4. Seams: Corresponding to direction of flow.

G. Form flashings from material shown or specified made up from sheets eight to 10 feet long with locked and soldered seams into units of not more than 16 feet. Join units together with three-inch wide loose-locked seams filled with sealant before units are joined. Runs of flashing shorter than 16 feet will not require loose-seam joints. Miter corners and join by locked and soldered joints.

H. Install expansion-joint covers as indicated and in accordance with manufacturer's recommendations. Splice ends of adjoining lengths of covers with neoprene tabs applied to both faces with approved adhesive. Provide prefabricated corners, intersections and crossovers.

I. Form cap flashing at parapet walls and other vertical surfaces to extend into metal reglets built into structure and prefilled with sealant. Lap built-up roof flashings and form metal to provide spring action against roof flashings. Prior to installation, coat flashing portions to be concealed with bituminous paint.

J. Where cants do not occur at intersections of roof decks and vertical surfaces of walls and other construction, provide flashings. Extend base flashings up vertical surfaces eight inches unless otherwise shown, behind metal cap flashing and out onto roof or horizontal surface not less than eight inches. Coat back sides of base flashing with bituminous paint and set into angle formed by roof and vertical surfaces after three plies of roofing-felt reinforcement have been laid. Nail flange with nails spaced three inches on centers and 3/4-inch from edge into wooden nailer provided in roof slab. Secure metal flashing at roof edges according to FM Loss Prevention Data Sheet 1-49 for specified wind zone.

K. Reglets: Form reglets to reproduce detail and design shown. Form sharp, even and true profiles, bends and intersections. Lock or lap joints and solder or reinforce joints as shown on approved shop drawings or specified. Install reglets to receive counterflashings: Furnish reglets for installation under Division 3 concrete and under Division 4 masonry.

L. Coping: Install coping in accordance with manufacturer's recommendations. Locate fasteners and clips as follows:
1. At joints and at five-foot maximum intervals.
2. Center butt joints over anchor clips.
3. Secure in place allowing for thermal expansion and establishing watertight joint.

M. Counterflashings: Coordinate installation of counterflashings with installation of assemblies to be protected by counterflashing. Install counterflashings in reglets or receivers. Secure in a waterproof manner by means of snap-in installation and sealant, lead wedges and sealant, interlocking folded seam, or blind rivets and sealant. Lap counterflashing joints a minimum of 2 inches and bed with sealant.

N. Roof-Drainage System: Install drainage items fabricated from sheet metal, with straps, adhesives, and anchors recommended by SMACNA's Manual or the item manufacturer, to drain roof in the most efficient manner. Coordinate roof-drain flashing installation with roof-drainage system installation. Coordinate flashing and sheet metal items for steep-sloped roofs with roofing installation. Install strainer at top of downspout.

O. Equipment Support Flashing: Coordinate equipment support flashing installation with roofing and equipment installation. Weld or seal flashing to equipment support member.

P. Roof-Penetration Flashing: Coordinate roof-penetration flashing installation with roofing and installation of items penetrating roof. Install flashing as follows:
1. Turn flashing down inside vent piping, being careful not to block vent piping with flashing.
2. Seal and clamp flashing to pipes penetrating roof, other than lead flashing on vent piping.

Q. Install continuous gutter screens on gutters with noncorrosive fasteners, arranged as hinged units to swing open for cleaning gutters.

R. Overhead-Piping Safety Pan: Suspend pans from pipe and install drain line to plumbing waste or drain line.

S. Splash Pans: Install where downspouts discharge on low-sloped roofs, unless otherwise shown. Set in roof cement or sealant compatible with roofing material.

T. Install sealant in accordance with Section 07900.

U. Install wood blocking in accordance with Section 06100.

3.03 CLEAN-UP:

A. Clean up rubbish and debris caused by this work and remove from site.

B. Promptly remove drippings and stains of materials from exposed surfaces.

C. Provide final protection and maintain conditions that ensure sheet metal flashing and trim Work during construction is without damage or deterioration other than natural weathering at the time of Substantial Completion.

END OF SECTION

SECTION 07730

ROOF ACCESSORIES

PART1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing roof hatches, equipment supports, roof vents, snow guards and miscellaneous roof accessories.

B. Related Work Specified Elsewhere:
1. Rough Carpentry: Section 06100.
2. Seals and Sealants: Section 07900.
3. Roof Anchors: Section 11010

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data: For each type of product indicated. Include construction details, materials, dimensions of individual components and profiles, and finishes.
2. Shop Drawings: Show fabrication and installation details. Indicate dimensions, weights, loadings, required clearances, method of field assembly, and components. Include plans, elevations, sections, details, and attachments to other Work.
3. Coordination Drawings: Roof plans drawn to scale and coordinating penetrations and roof-mounted items. Show the following:
   a. Size and location of roof accessories specified in this Section.
   b. Method of attaching roof accessories to roof or building structure.
   c. Other roof-mounted items including mechanical and electrical equipment, ductwork, piping, and conduit.
4. Samples for Verification: For each type of exposed finish required, prepared on Samples in manufacturer's standard sizes, and of same thickness and material indicated for the Work. If finishes involve normal color or shade variations, include sample sets showing the full range of variations expected. Provide a mock-up of custom-fabricated items
5. Certification.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. NRCA: Roofing and Waterproofing Manual.
3. SMACNA: Architectural Sheet Metal Manual.
4. ASTM: A653, A729, A780, B209, B221, C920, C1036, D256, D4586, E527.
5. UL 793, 972.
6. SSPC - Paint 12
7. NFPA: 204M.
8. NAAMM.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, type, class and rating as applicable.

B. Store products in approved dry area and protect from contact with soil and from exposure to the elements.

C. Handle products to prevent breakage of containers and damage to products.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL:

A. Aluminum Sheet: ASTM B 209 for alclad alloy 3005H25 or alloy and temper required to suit forming operations, with mill finish, unless otherwise indicated

B. Extruded Aluminum: ASTM B 221 alloy 6063-T52 or alloy and temper required to suit structural and finish requirements, with mill finish, unless otherwise indicated

C. Galvanized Steel Sheet: ASTM A 653 with G90 coating designation; commercial quality, unless otherwise indicated.
   1. Structural Quality: Grade 40, where indicated or as required for strength.

D. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792 with Class AZ-50 coating, structural quality, Grade 40, or as required for strength.

E. Plastic Sheet: Unless additional thickness is required for light transmittances, provide glazing plastic sheet thickness required for 40-lbf/sq. ft. external and 20-lbf/sq. ft. internal loading pressures as recommended by the manufacturer for the size and shape indicated.
   1. Polycarbonate: Thermoformable, monolithic polycarbonate sheets manufactured by the extrusion process, burglar-resistance rated per UL 972 with average impact strength of 16 ft-lbf/in. of width when tested according to ASTM D 256, Method A (Izod)

F. Insulation: Manufacturer's standard rigid or semirigid glass-fiber board of thickness indicated.

G. Wood Nailers: Not less than 1-1/2 inches thick complying with Section 06100.

H. Fasteners: Same metal as metals being fastened, or nonmagnetic stainless steel or other noncorrosive metal as recommended by manufacturer. Match finish of exposed fasteners with finish of material being fastened.
   1. Where removing exterior exposed fasteners affords access to building, provide nonremovable fastener heads.

I. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, or PVC; or flat design of foam rubber, sponge neoprene, or cork.

J. Bituminous Coating: SSPC-Paint 12, solvent-type bituminous mastic, nominally free of sulfur and containing no asbestos fibers, compounded for 15-mil dry film thickness per coating.

K. Mastic Sealant: Polyisobutylene; nonhardening, nonskinning, nondrying, nonmigrating sealant.

L. Elastomeric Sealant: Generic type recommended by unit manufacturer that is compatible with joint surfaces; ASTM C 920, Type S, Grade NS, Class 25, and Uses NT, G, A, and, as applicable to joint substrates indicated, O and in accordance with Section 07900.

M. Roofing Cement: ASTM D 4586, nonasbestos, fibrated asphalt cement designed for trowel application or other adhesive compatible with roofing system.

2.02 ROOF CURBS AND EQUIPMENT SUPPORTS:

A. General: Provide roof curbs capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported on roof curbs. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

B. Fabrication: Unless otherwise indicated or required for strength, fabricate units from minimum 0.0747-inch thick, structural-quality, hot-dip galvanized or aluminum-zinc alloy-coated steel sheet; factory primed and prepared for painting with welded or sealed mechanical corner joints.

2.03 ROOF HATCHES:

A. General: Fabricate units to withstand 40-lbf/sq. ft. external and 20-lbf/sq. ft.internal loading pressure. Frame with minimum 9-inch- high, integral-curb, double-wall construction with 1-1/2-inch insulation, formed cants and cap flashing (roofing counterflashing), with welded or sealed mechanical corner joints. Provide double-wall cover (lid) construction with 1- inch-thick insulation core. Provide gasketing and equip with corrosion-resistant or hot-dip galvanized hardware including pintle hinges, hold-open devices, interior padlock hasps, and both interior and exterior latch handles.

B. Type: Single-leaf personnel access.
   1. For Ladder Access: 30 by 36 inches.
   2. For Ship's Ladder Access: 30 by 54 inches.
      a. For Stair Access: 30 by 102 inches.

C. Type: Double leaf for equipment access.
   1. Size: 72 by 96 inches.

D. Material and Finish: Galvanized steel, baked enamel.

E. Sloping Roofs: Where slope or roof deck exceeds 1/4 inch per foot (1:48), fabricate hatch curbs with height tapered to match slope to level tops of units.

2.04 SMOKE VENTS:

A. General: Automatically operated roof vents for heat and smoke constructed to operate (open) without power source that could be interrupted during a fire. Custom fabricate units only to extent necessary to comply with indicated dimensions and other special requirements.

B. Live Load and Uplift: Unless otherwise indicated, fabricate to withstand a minimum 10-lbf/sq. ft. external live load and 30-lbf/sq. ft. uplift.

C. Regulatory Requirements: Comply with provisions of the following:
   1. UL 793, for construction and performance of automatically operated roof vents for heat and smoke
   2. NFPA 204M, for heat-and-smoke vent design constraints, operation, size, and location.\

D. Framing: Fabricate from the following materials, with manufacturer's standard welded or sealed mechanical corner joints, including cap flashing (roofing counterflashing):
   1. Material: Formed sheet or extruded aluminum or galvanized steel, at Contractor's option
      a. Finish: Baked enamel.
      b. Finish: High-performance organic coating.
   2. Unit Support: Double-wall curb construction with 1-inch insulation, of height indicated or, if not indicated, for mounting with height minimum 9 inches above roof membrane.
      a. Provide formed cants and base profile coordinated with roof type and insulation thickness.
   3. Sloping Roofs: Where slope of roof deck exceeds 1/4 inch per foot(1:48), fabricate curbs with height tapered to match slope to level tops of units.

E. Dome-Type Units: Manufacturer's standard gravity-opened, shrink-back and drop-out, acrylic or PVC sheet, dome unit for 165 deg F activation. Provide glazing system for easy replacement of activated domes and for drainage of condensation to exterior.
   1. Inner Double-Dome Color: Bronze.

2.05 SNOWGUARDS:

A. L-shaped stop-type, metal or plastic.

B. Provide in accordance with approved mock-up sample.

2.06 FINISHES, GENERAL:

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.07 ALUMINUM FINISHES:

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. Conversion-Coated and Factory-Primed Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below).
   1. Organic Coating: Air-dried primer of not less than 2.0-mil0.5-mm dry film thickness.

C. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting. Below references AAMA standard for pigmented organic coating on extrusions. Color as selected by the Authority's representative.

D. High-Performance Organic Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight. Color as selected by the Authority's representative.

2.08 GALVANIZED STEEL SHEET FINISHES:

A. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas, and apply galvanizing repair paint specified below to comply with ASTM A 780.
   1. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

B. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Comply with manufacturer's written instructions. Coordinate installation of roof accessories with installation of roof deck, roof insulation, flashing, roofing membranes, penetrations, equipment, and other construction involving roof accessories to ensure that each element of the Work performs properly and that combined elements are waterproof and weather tight. Anchor roof accessories securely to supporting structural substrates so they are capable of withstanding lateral and thermal stresses, and inward and outward loading pressures

B. Install roof accessory items according to construction details of NRCA's "Roofing and Waterproofing Manual," unless otherwise indicated,

C. Separation: Separate metal from incompatible metal or corrosive substrates, including wood, by coating concealed surfaces, at locations of contact, with bituminous coating or providing other permanent separation.

D. Flange Seals: Unless otherwise indicated, set flanges of accessory units in a thick bed of roofing cement to form a seal.

E. Cap Flashing: Where required as component of accessory, install cap flashing to provide waterproof overlap with roofing or roof flashing (as counterflashing). Seal overlap with thick bead of mastic sealant.

F. Operational Units: Test-operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.

G. Heat-and-Smoke Vents: Locate, install, and test according to NFPA 204M.

H. Install wood nailers in accordance with Section 06100.

I. Install sealants in accordance with Section 07900.

J. Adhere snow guards to sheetmetal roofing by approved silicone sealant as specified in Section 07900. Locate and space snow guards in accordance with manufacturer’s recommendations. Where snow guards are located on standing seams, provide approved mechanical fastenings.

3.02 CLEANING AND PROTECTION:

A. Clean exposed surfaces according to manufacturer's written instructions. Touch up damaged metal coatings.

END OF SECTION

SECTION 07841
FIRESTOPPING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This Section perimeter fire containment systems and specifies through-penetration firestop systems for penetrations through the following fire-resistance-rated assemblies:
   1. Floors.
   2. Roofs.
   3. Walls and partitions.
   4. Construction enclosing compartmentalized areas.
   5. Smoke barriers

B. Related Work Specified Elsewhere:
   1. Cast-in-Place Structural Concrete: Section 03300 for construction of openings in concrete slabs and walls.
   2. Division 15 Sections specifying duct and piping penetrations.
   3. Division 16 Sections specifying cable and conduit penetrations.

1.02 PERFORMANCE REQUIREMENTS:

A. General: For the following constructions, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly penetrated.
   1. Fire-resistance-rated non-load-bearing walls, including partitions, with fire-protection-rated openings.
   2. Fire-resistance-rated floor assemblies
   3. Fire-resistance-rated roof assemblies.

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B. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, as determined per ASTM E 814, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.

C. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, as determined per ASTM E 814, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:
   1. Penetrations located outside wall cavities.
   2. Penetrations located outside fire-resistive shaft enclosures.
   3. Penetrations located in construction containing fire-protection-rated openings.
   4. Penetrating items larger than 4-inch diameter nominal pipe or 16 sq. in. in overall cross-sectional area.

D. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that after curing do not deteriorate when exposed to these conditions both during and after construction.
   1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
   2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved either by installing floor plates or by other means.

3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

E. For through-penetration firestop systems exposed to view, provide products with flame-spread ratings of less than 25 and smoke-developed ratings of less than 450, as determined per ASTM E 84.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:

B. Product Data: For each type of through-penetration firestop system product indicated.

C. Shop Drawings: For each through-penetration firestop system, show each kind of construction condition penetrated, relationships to adjoining construction, and kind of penetrating item. Include firestop design designation of testing and inspecting agency acceptable to authorities having jurisdiction that evidences compliance with requirements for each condition indicated.
1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetrating items.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Certification: Signed by manufacturers of through-penetration firestop system products certifying that products furnished comply with requirements.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM E 84, E 814.
3. UL - 1479.

B. Installer Qualifications: An experienced installer who has completed through-penetration firestop systems similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

C. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.

D. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in "Performance Requirements" Article:
1. Through-penetration firestop systems are identical to those tested per ASTM E 814. Provide rated systems complying with the following requirements:.
   a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.
   b. Through-penetration firestop systems correspond to UL in Fire Resistance Directory reference to through-penetration firestop system designations listed by the following:

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1.05 DELIVERY, STORAGE, AND HANDLING:

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to Project; curing time; and mixing instructions for multicomponent materials.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.06 PROJECT CONDITIONS:

A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.07 COORDINATION:

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

C. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until the Engineer has examined each installation.

PART 2 - PRODUCTS

2.01 FIRESTOPPING, GENERAL:

A. Compatibility: Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by the qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:
    a. Slag-/rock-wool-fiber insulation.
    b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
    c. Fire-rated form board.
    d. Fillers for sealants.
2. Temporary forming materials.

3. Substrate primers.
4. Collars.
5. Steel sleeves.

2.02 FILL MATERIALS:

A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by reference to the types of materials described in this Article. Fill materials are those referred to in directories of the referenced testing and inspecting agencies as fill, void, or cavity materials.

B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture

D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.

F. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

H. Mortars: Prepackaged, dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

I. Pillows/Bags: Reusable, heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents and fire-retardant additives.

J. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

K. Silicone Sealants: Moisture-curing, single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:
1. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
2. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

2.03 PERIMETER FIRE-CONTAINMENT SYSTEMS:

A. Where indicated for gaps between the perimeter edge of fire-resistance-rated floor assemblies and non-fire-resistance-rated exterior curtain walls, provide a perimeter fire-containment system with the fire-test response characteristics indicated, as determined by

testing identical systems per UBC Standard 26-9 and UL 2079 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Materials shall be identified with appropriate markings of applicable testing and inspecting agency.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:
   1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
   2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.03 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION:

A. General: Install through-penetration firestop systems to comply with "Performance Requirements" Article and firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

C. Install fill materials for firestop systems by proven techniques to produce the following results:
   1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
   2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
   3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.04 FIELD QUALITY CONTROL:

A. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.

3.05 IDENTIFICATION:

A. In areas not exposed to public view, identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:
1. The words: "Warning--Through-Penetration Firestop System--Do Not Disturb."

3.06 CLEANING AND PROTECTION:

A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce through-penetration firestop systems complying with specified requirements.

3.07 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE:

A. Where UL-classified systems are indicated, they refer to the alpha-alpha-numeric designations listed in UL's "Fire Resistance Directory" under product Category XHEZ.

B. Firestop Systems for Metallic and Non-metallic Conduit, Tubing, Sleeves, Cable Trays and Cables:
1. UL-1479: Fire rated for 3 hours.
2. Type of fill materials: One or more of the following:
   a. Silicone sealant.
   b. Intumescent putty.
   c. Silicone foam.

C. Firestop Systems for Insulated Pipes: Comply with the following:
1. UL- 1479: CAJ 5087.
2. Type of Fill Materials: Intumescent putty.

D. Firestop Systems for Miscellaneous Mechanical Penetrations: Comply with the following:
1. UL- 1479: CAS 8033.
2. Type of Fill Materials: Mortar.

E. Firestop Systems for Ductwork: Comply with the following:
1. UL- 1479: WJ7007.
2. Type of Fill Materials: Intumescent sealant.

END OF SECTION

SECTION 07900

SEALS AND SEALANTS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing compression seals and sealants not specified elsewhere.

B. Related Work Specified Elsewhere:
1. Rabbet for compression seal in granite edging: Section 04415.
2. Expansion joint cover assemblies and systems: Sections 05810 and 05811.
3. Sealant for metal thresholds: Section 08710.
4. Glazing sealant: Section 08800.
5. Acoustical sealant: Section 09255.
6. Ceramic tile sealant: Section 09320.
7. Caulk for painting preparation: Section 09920.
8. Paver tile sealant: Section 09340.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: C920, C1193, D412, D1752, D2628.

B. Manufacturer Qualification:
1. General: Provide the products of established manufacturers. Insofar as possible, provide products from a single manufacturer.
2. Sealant color-selection capability: Have color-selection capability resolved early in the submittals process to prevent delay of the work.
   a. Where sealants are exposed, provide products of a manufacturer who can match the colors of adjacent materials by either having an acceptable range of standard colors or by factory blending custom colors as acceptable to the Engineer and at no additional cost to the Authority.
   b. Where a manufacturer's colors are insufficient for proper color-match, use acceptable colors from another acceptable manufacturer.
3. On-site representation: Use only a sealant manufacturer who has a local, knowledgeable representative who can visit the project site prior to construction and at least twice during sealant installation to observe conditions and recommend solutions at no additional cost to the Authority.

C. Design Criteria:
1. Designed width of exterior joints: Joint widths indicated on drawings are shown at their designed width. This is measured when the joint would be at the average air temperature for the year, which is approximately 50F, based on an average minimum air temperature of zero degrees F and an average maximum air temperature of 100F.
2. Designed width of interior joints: Joint widths indicated on the drawings are shown at their designed width at 50F.
3. Joint width at time of seal or sealant application: Make joint widths at time of installation never less than the calculated width, which at 0 degrees F is 25 percent wider than the designed width and at 100F is 25 percent narrower than the designed width for exterior joints and 1-1/2 percent smaller than the designed width for each

degree the ambient temperature exceeds 50F, and 1-1/2 percent larger than the designed width for each degree the ambient temperature is less than 50F.

a. It is recommended that seals and sealant be installed when the average daily air temperature is 50 degrees F plus or minus five degrees, when joint should be at its designed width.

b. If joints are less than the calculated width at the time of proposed installation, take corrective action, which may include saw cutting of joint or other remedial measures approved by the Engineer and by the seal or sealant manufacturer.

c. If the joint depth is not sufficient for the designed width of the joint, sealant and backup, cut out the joint to the required depth for the sealant and backup.

d. Perform cutting and remedial measures that are acceptable to the Engineer. Cost of cutting and remedial measures are at no additional cost to the Authority.

4. Joint size and sealant size: Except as otherwise indicated, make sealant at least 1/4-inch wide x 1/4-inch deep. In joints 3/8 inches wide, make sealant 1/4-inch deep. In joints wider than 3/8-inch and up to 1-inch wide, make sealant depth 1/2 of the joint width. For joints wider than 1 inch, make sealant depth as recommended by the sealant manufacturer.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Samples:

a. Material samples: Four of each type of the following materials used in the work:

1) Compression seals: 12 inches long, plus each factory-made corner unit.

2) Sealant and lubricant-adhesive: Half-pint containers.

3) Sealant colors: Fully cured beads of each color used, each six inches long.

4) Backup material: 12 inches long.

5) Joint filler: 12 inches long.

6) Color chips: 12 inches long, one for each color used in the work.

b. Demonstration samples: Make demonstration installation of each seal and sealant installation type and color. Use approved materials, installed and cured as required. Remove demonstration samples as directed. Perform testing on sealant demonstration samples as specified under Field Testing.

2. Shop Drawings:

a. General: Submit manufacturers technical product data for each product proposed to be used, together with standard and custom color-selection samples.

b. Compression seals: Detail correct size and placement of each type and size of compression seal in its joint.

c. Test results: Inspection and adhesion test results performed by sealant manufacturer.

3. Certification by each manufacturer that the products provided will perform as required and will not stain adjacent materials.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to jobsite in original unopened containers clearly marked with manufacturer's name and brand designation, referenced specification number, type and class as applicable.

B. Store products in approved dry area and protect from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products to prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Application of seals or sealants, including their related products, when ambient temperature is lower than 40F or when there is ice, frost or dampness visible on surfaces to be sealed is prohibited.
2. Comply with manufacturer's environmental recommendation.

PART 2 - PRODUCTS

2.01 COMPRESSION-SEAL MATERIALS:

A. Preformed compression seals: ASTM D2628, rectangular design unless otherwise shown.
1. Width: Size compression seals for full amount of joint movement as required, plus the thickness of the compressed seal as recommended by the manufacturer.
2. Corners: Provide factory pre-molded or factory pre-cut and welded corner units for angular changes in direction, vertically as well as horizontally, including 30, 60, 45, 90, 120, 135, and 150 degrees as required by joint location.

B. Lubricant-adhesive, general: One-part moisture-curing polyurethane as recommended by compression seal manufacturer, with the following additional requirements:

Physical Property	Requirement	ASTM Test Method
Average weight per gallon	8.00 pounds plus-or-minus 10 percent	-
Solids content	65 - 74 percent by weight	-
Adhesive	Fluid from 5F to 120F	-
Film strength	1200 psi, minimum	D412
Elongation	250 percent	D412

C. Lubricant-adhesive for compression seal in granite: Same as above, but also tested for nonstaining over a three-month period on samples of granite to be used.

2.02 SEALANT AND ACCESSORIES:

A. General: Provide joint sealant, backup rod, primer, and other related materials that are compatible with one another and with the joint substrates under conditions of service and application, as demonstrated by sealant manufacturer based on field experience and submitted test reports.

B. Sealant (Polyurethane): Polyurethane-based or epoxidized polyurethane based, multi-part elastomeric sealant, ASTM C920, Type M (multi-component), Class 25 (withstands an increase or decrease of 25 percent of the joint width) as follows:
   1. For joints in horizontal surfaces: Grade P (pourable or self-leveling), Uses T (traffic areas), M (on masonry) or O (other than standard substrates).
   2. For joints in sloped surfaces: Grade NS (nonsag), Uses T (traffic areas), M (on masonry) or O (other than standard substrates).
   3. For joints in overhead and vertical surfaces: Grade NS (nonsag), Uses NT (nontraffic areas), M (on masonry), A (on aluminum), or O (other than standard substrates).

C. Primer: Colorless, nonstaining liquid material of types suited to each substrate surface, as tested and recommended in writing by the manufacturer of each sealant to be used.

D. Backup Rod: Preformed, compressible, resilient, non-waxed, non-extruding, nonstaining, closed-cell rod stock of polyethylene or polyethylene-jacketed foam which will maintain a uniform round or oval cross-sectional shape when compressed into the joint.
   1. Select backup rods as recommended by the manufacturer of each sealant to be used; compatible with joint substrates, sealants, primers, and other joint fillers; that will not bond with sealants and primers; and are approved for applications indicated based on field experience and laboratory testing.
   2. Select backup rod of the sizes and shapes to suit the various conditions and at about 30 percent wider than the joint width.
      a. Where depth of joint is too shallow for round backup rod use 1/2-round backup rod, factory manufactured with cut surface fused by heat process so that it cannot release gas.
      b. Where depth is too shallow for 1/2-round rod, use bond breaker tape.

E. Bond-Breaker Tape: Polyethylene tape, as recommended by the manufacturer of each sealant to be used, for preventing sealant from adhering to joint-filler materials or joint surfaces at back of joint where such adhesion would promote sealant failure, or result in less than optimal performance. Provide tape sized properly for the joint. Provide self-adhesive tape where applicable.

F. Cleaning Agent: Joint cleaning compound tested and recommended in writing by sealant manufacturer for cleaning joint surfaces before priming. Use only a cleaner which is nonstaining, non-harmful to masonry, does not leave oily residues, and does not have a detrimental effect on adhesion or in-service performance.

G. Weep Tubes: Vinyl tubing, 3/8-inch diameter.

H. Masking Tape: Nonstaining, nonabsorbent type, compatible with joint sealants and to surfaces adjacent to joints. Use only a masking tape which will easily come off entirely, including adhesive.

I. Joint Filler for Sealant Joints : Nonstaining joint filler compatible with backer rod and sealant:
   1. Sponge rubber: Preformed strips complying with ASTM D1752 Type I.

J. Joint Filler for Pavers and Walkways: Nonstaining joint filler compatible with backer rod and sealant; one of the following. Where filler is not shown covered by sealant, see Section 03300:
   1. Cork: Preformed strips complying with ASTM D1752 Type II.

2. Self-expanding cork: Preformed strips complying with ASTM D1752 Type III.

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION:

A. Inspection:
1. With installer present, examine joints for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting the performance of joint seals and sealants.
2. Have sealant manufacturer's representative visit the site and review the project joint conditions and details for sealant work of this Project and perform adhesion testing. Have sealant manufacturer representative report to the Engineer in writing the results of his inspections and tests.
3. Do not proceed with work of this section until unsatisfactory conditions have been corrected.

B. Preparation: Comply with the recommendations of ASTM C1193 and the following:
1. Cleaning:
   a. Clean joint surfaces receiving seals or sealants. Ensure that they are sound, smooth, clean, dry, and free of foreign substances and contaminants, including curing compounds and release agents.
   b. Remove factory or field-applied coatings that will be detrimental to adhesion of seals, sealants or primers.

2. Masking: Use masking where required to prevent contact of sealant and primers with adjoining surfaces that otherwise would be stained or damaged by such contact or by cleaning methods required to remove sealant or primer smears.

C. Priming: Unless sealant manufacturer specifically recommends in writing against priming, apply primer to prepared surfaces that will receive sealant. Apply primer on clean, dry surfaces, and prior to installation of backup rod. Completely wet both inner faces of the joint with primer.

D. Backup rod: Install backup rod in joints (after primer is dry) to provide backup and give proper shape for sealant bead. Where there is insufficient joint depth for backup rod, install half-round backup rod or bond breaker tape as approved in lieu of backup rod.
1. Proper cross-sectional shape for sealant bead is a very slight hourglass shape with back and front faces having slight concave curvature, unless indicated otherwise. Use special blunt T-shaped tool or roller to install backup rod to the proper and uniform depth required for the sealant.
2. Install size of backup rod that will provide approximately 30 percent compression.
3. Do not stretch, twist, braid, puncture, or tear backup rod. A broken surface will emit gas (out-gassing) that blisters the installed sealant, thereby requiring complete removal and reinstallation of primer, backup rod, and sealant.
4. Tightly butt backup rods at joints and intersections. At outside corners, provide sufficient length of backer rod so that rod can be bent around corner rather than cut at corner, so that out-gassing will not occur.

E. Bond breaker tape: Where space for a backup rod is inadequate, use bond breaker tape to prevent three-sided adhesion. Install bond breaker tape smoothly over back of joints so that sealant adheres to the sides of joint but not to the back of joint.

3.02 INSTALLATION:

A. Compression Seals:

1. If adjacent surfaces are to receive waterproofing, install compression seals prior to application of waterproofing.
2. Prime interfaces, edges and corners of joints as necessary.
3. Prime and lubricate joints by coating both sides of joint with lubricant-adhesive to wet-film thickness of 20 mils.
4. While lubricant-adhesive is still wet, install compression seals to depth shown.
5. Recess exposed edges slightly behind adjoining surfaces, unless otherwise shown, so that compressed units will not protrude from joints.
6. Bond ends together with materials and methods recommended by manufacturer to ensure continuous watertight and airtight performance. Where factory pre-molded or pre-welded corner units are unavailable, miter-cut and bond ends at corners.

B. Sealant:

1. Comply with ASTM C1193 and with manufacturer's recommendations, except where more stringent requirements are shown or specified.
2. Set joint-filler units at depth or position in joint as shown to coordinate with other work, including installation of bond breakers, backer rods and sealants. Do not leave voids or gaps between ends of joint-filler units.
3. Install back-up material, except where shown to be omitted or recommended to be omitted by sealant manufacturer for application used.
4. Install bond-breaker tape where shown and where recommended by manufacturer to ensure that sealants will perform as intended.
5. Employ installation techniques which will ensure that sealants are deposited in uniform, continuous ribbons without gaps or air pockets, with complete wetting of joint bond surfaces equally on opposite sides.
    a. Except as otherwise shown, fill sealant rabbet to slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between horizontal surface and vertical surface, fill joint to form slight cove, so that joint will not trap moisture and dirt.
    b. Fill joints to a depth equal to 50 percent of joint width, but not more than 1/2-inch deep nor less than 1/4-inch deep.
    c. Ensure that temperature of sealant, as well as of substrates, at time of sealant application, is as recommended by sealant manufacturer and as specified herein. Apply sealant at optimum time after primer application.
    d. Remove masking immediately after tooling of sealant and before sealant face starts to skin over. Do not cause dislocation of sealant, or migration of sealant to adjacent surfaces when removing masking tape.
6. Spillage: Do not allow sealants or compounds to overflow from confines of joints, to spill onto adjoining work or to migrate into voids of exposed finishes. If spillage occurs, eliminate evidence of spillage to the Engineer’s satisfaction.
7. Seal joints in granite work with sealant, except granite-paving joints and pylon-apron joints that are shown to be grouted. Ensure joint depths of at least 3/4 inch before placing backup. If necessary, rake-out joints to a minimum depth of 3/4 inch.
8. Weep Holes: Install weep tubes, sloping to expel water, where required to allow free drainage of hollow spaces. Where so shown, install tubes through sealant and backing to ensure an unobstructed drainage path. Do not seal over weep holes provided by other trades.

3.03 CURING AND PROTECTING:

A. Cure sealants in compliance with manufacturer's recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.

B. Cure and protect joint sealers during construction period, so that they will be without deterioration, soiling or damage, other than normal wear and weathering, at time of final acceptance.

C. Cure and protect sealants so as to minimize increases in modulus of elasticity and other accelerated aging effects.

D. Replace or restore sealants damaged or deteriorated during construction and from testing as directed. Cut out or remove damaged sealant immediately and properly prepare and reseal joint with new materials to produce sealant installation with repaired areas indistinguishable from other work.

3.04 FIELD TESTING:

A. Sealant: Field test cured sealant installations in the presence of and where directed by the Engineer. Test each type of joint sealant for adhesion to joint substrates by hand-pull method as follows:

1. Make knife cuts as follows: A transverse cut from one side of joint to the other, followed by parallel cuts approximately 2 inches long at each side of joint and meeting the transverse cut at the end of the 2-inch cuts. Place a mark 1 inch from the top of 2-inch piece.
2. Use fingers to grasp the 2-inch piece of sealant just above the 1-inch mark; pull firmly away at a 90-degree angle while holding a ruler along side of sealant; pull sealant out of joint to the distance recommended by sealant manufacturer for testing adhesive capability, but not less than the distance equaling the specified maximum movement capability in extension; hold this position for 10 seconds.
3. Report whether or not the sealant in joint (connected to pulled-out portion) failed to adhere to joint substrates or failed cohesively or adhesively. Include data on pull distance used to test each type of sealant and joint substrate.
4. Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered acceptable, subject to certification of design and performance criteria by the manufacturer.
5. Make a minimum of 10 such tests unless otherwise directed by the Engineer. Submit report of testing to the Engineer.

3.05 CLEANING:

A. Immediately clean off excess primers, drippings, sealants and sealant smears as work progresses, using methods and with cleaning materials approved by manufacturer of each joint primer and sealant and by manufacturers of materials where joints occur.

B. Use only materials and methods acceptable to the Engineer.

END OF SECTION

SECTION 08110

HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing metal doors and frames.

B. Related Work Specified Elsewhere:
   1. Finish hardware: Section 08710.
   2. Glass and glazing: Section 08800.
   3. Field painting: Section 09920.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Details of construction, connections, anchors, schedules, setting diagrams and interface with work of other trades.
      b. Schedule of doors and frames using the same reference numbers for details and openings as those on the Contract Documents.
   2. Certification.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. NFPA: 80 (Standard for Fire Doors and Fire Windows).
   3. UL: Building Materials Directory.
   4. NAAMM: Standards HMMA 861 and 862.
   5. SDI: 100.
   6. FS: TT-F-322.
   7. ASTM: A153, A366, A526, A569, A780, C236, C976.
   8. DHI (Door and Hardware Institute): A115, Recommended Locations for Builder's Hardware.
   9. ADA (Americans With Disabilities Act).

B. Fire-Rated Assemblies: Where UL-listing, UL-label or UL Building Materials Directory is specified, another testing and inspection agency acceptable to the Engineer and to authorities having jurisdiction may be used.

1.04 PRODUCT, DELIVERY, STORAGE AND HANDLING:

A. Deliver products to the jobsite in original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, door schedule number, referenced specification number, type, class and rating as applicable.

B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements.

C. Handle products so as to prevent breakage of containers and damage to products.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Hot-Rolled Steel Sheets and Strip: Commercial quality carbon steel, pickled and oiled, complying with ASTM A569, free of scale, pitting or surface defects.

B. Cold-Rolled Steel Sheets: Commercial quality, level, carbon steel, complying with ASTM A366.

C. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A526, G60 zinc coating, mill phosphatized.

D. Shop-Applied Primer: Rust-inhibitive baked-on primer, suitable as base for specified finish paint systems.

E. Finish Paint Systems: Section 09920.

F. Supports and Anchors: Sheet steel, gauge in accordance with HMMA reference standards, unless specified otherwise. After fabricating, galvanize units to be built into or attached to exterior walls, wet areas such as doors to toilet rooms and janitor's room, or attached to slabs on grade; complying with ASTM A153, Class B.

G. Inserts, Bolts and Fasteners: Manufacturer's standard units unless specified otherwise. Hot-dip galvanized items to be used in exterior walls, wet areas such as doors to toilet rooms and janitor's rooms, or attached to slabs on grade; complying with ASTM A153, Class C or D as applicable.

H. Metallic Filler: FS TT-F-322.

I. Galvanizing Repair Compound: Stick form, melting point 600F to 650F, GALVABAR or equal.

2.02 FABRICATION, GENERAL:

A. Fabricate hollow metal door and frame units to be rigid, neat in appearance, and free from defects, warp or buckle. Wherever practicable, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to ensure proper assembly at project site.

B. Galvanize exterior door and frame assemblies, and wet area door and frame assemblies such as at toilet room and janitor's room; including but not limited to face sheets, reinforcements, closures, dust covers, mortar shields, glazing and louver beads, clips, anchor bolts, screws, rivets and welds.

C. Exposed fasteners are not allowed on door frames and door faces; elsewhere, provide countersunk flat philips heads for exposed screws and bolts.

D. Door Hardware Preparation:
   1. Prepare and reinforce doors and frames to receive mortised and concealed hardware in accordance with final Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of DHI A115-series, Steel Door Prep Standards, for door and frame preparation for hardware.
   2. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at project site.

3. Locate hardware as indicated on approved shop drawings or, if not indicated, in accordance with ADA requirements pertaining to operating hardware locations, and the Recommended Locations for Builder's Hardware, published by the DHI.

E. Shop Painting:
1. Clean, treat and paint exposed surfaces of steel door and frame units, including galvanized surfaces.
2. Chemically clean steel surfaces of mill scale, rust, oil, grease, dirt and other foreign materials before application of paint.
3. Apply phosphate conversion pretreatment coating.
4. Apply shop coat of prime paint of even consistency to provide a uniformly finished surface ready to receive finish paint. Apply primer immediately after surface preparation and pretreatment.

F. Insulated Metal Assemblies: Where schedules, provide doors and frames fabricated as thermal-insulating assemblies and tested according to ASTM C236 or ASTM C976.

2.03 FRAMES:

A. General:
1. Fabricate frames to uniform profile as shown of full-welded unit construction, with corners mitered and reinforced. Continuously weld full depth and width of frame, except for knock-down frames.
2. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated.
   a. Fasten mullions and transom bars at crossings and to jambs by butt welding, except for knock-down frames.
   b. Reinforce joints between frame members with concealed clip angles or sleeves of the same metal and thickness as frame.
3. Jamb anchors: Provide in accordance with NAAMM Standards HMMA 861 and 862:
   a. Provide T-type anchors or strap-and-stirrup type anchors at new masonry.
   b. Provide Z-type anchors at metal stud partitions.
   c. Provide bolt-type anchors with pipe spacers at in-place construction.
4. Floor anchors: Provide floor anchors for each jamb and mullion that extends to floor, formed of galvanized steel sheet, as follows:
   a. Monolithic concrete slabs: Clip-type anchors, with two holes to receive fasteners, welded to bottom of jambs and mullions.
   b. Separate topping concrete slabs: Adjustable type with extension clips, allowing not less than two-inch height adjustment. Terminate bottom of frames at finish floor surface.
5. Head anchors: Provide two anchors at head of frames exceeding 42 inches wide for frames mounted in steel stud walls.
6. Head strut supports:
   a. Provide 3/8-inch by two-inch vertical steel struts extending from top of frame at each jamb to supporting construction above, unless frame is anchored to masonry or to other structural support at each jamb.
   b. Bend top of struts to provide flush contact for securing to supporting construction above.
   c. Provide adjustable bolted anchorage to frame jamb members.
7. Structural reinforcing members: Provide structural reinforcing members as a part of frame assembly, where indicated at mullions, transoms or other locations which are to be built into frame.
8. Spreader bars: Across bottom of welded frames, provide removable spreader bar, tack welded to jambs and mullions.
9. Door silencers:

a. Drill stop to receive three silencers on single door frames and two silencers on double door frames.
b. Install plastic plugs to keep holes clear during construction.

10. Plaster guards: Provide 18-gauge steel plaster guards or dust-cover boxes (galvanized at exterior locations), welded to frame, at back of hardware cutouts, where mortar or other materials might obstruct hardware installation or operation and to close off interior of openings.

B. Interior Hollow Metal Frames: NAAMM Standard HMMA 861, Guide Specifications for Commercial Hollow Metal Doors and Frames except as follows:
1. Openings over four feet wide: 12-gauge.
2. Cart-storage rooms and other doors as indicated: Use security hollow metal frames specified below.
3. Knock-down frames may be used in drywall construction as specified below.

C. Exterior and Security Hollow Metal Frames: NAAMM Standard HMMA 862, Guide Specifications for Security Hollow Metal Doors and Frames, except as follows:
1. Use for exterior doors and for indicated security doors including cart-storage room.
2. Cart-storage-room frame anchors: Hot-dipped galvanized anchor bolts, not less than 1/-2-inch by six inches, inaccessible from the safety walk, eight per frame.

D. Interior Knock-Down Hollow Metal Frames: SDI 100, and as follows:
1. Knock-down frames may be used only in interior drywall construction.
2. Openings four foot wide or less: 16-gauge.
3. Openings over four feet wide: 12-gauge.

2.04 DOORS:

A. Thermal Insulation: Provide exterior doors and panels with internal thermal insulation of extruded polystyrene. Aged R-value of door or panel is to be 5.0 or greater.

B. Interior Hollow Metal Doors: NAAMM Standard HMMA 861, Guide Specifications for Commercial Hollow Metal Doors and Frames except for cart-storage room and other doors as indicated.

C. Exterior and Security Hollow metal Doors: NAAMM Standard HMMA 862, Guide Specifications for Security Hollow Metal Doors and Frames.
1. Use for exterior doors and for indicated security doors including cart-storage room.

2.05 FIRE-DOOR ASSEMBLIES:

A. Where fire-rated door and frame assemblies are required for code compliance, or are otherwise indicated, provide door, frame and hardware assemblies in compliance with NFPA 80, which are labeled and listed by UL.

B. Fabrication and assembly requirements necessary to obtain labels will take precedence over requirements shown or specified, except where requirements shown or specified exceed sizes or gauges required for labeling.

C. Where oversized fire doors are required, furnish manufacturer's certification that assembly has been constructed with materials and methods equivalent to labeled construction.

D. Louvers: Equip louvers in fire-rated doors with UL-listed self-closing fire dampers with fusible links.

E. Identify each fire door and frame with permanent UL labels, indicating the applicable fire rating of both the door and the frame. Secure labels to vertical edge of doors and frames where readily visible. Protect labels from painting operations.

2.06 TRANSOM ASSEMBLIES:

A. Removable Transom Bar: Formed as shown of same material as frame, with manufacturer's standard bolted connection.

B. Removable Transom Panel: Formed as shown of the same construction as the door or doors below, through-bolted to frame eight inches on-center maximum.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Deliver work, ready to set up and erect in place as rapidly as general construction work permits. Set work in place in accordance with approved shop drawings, plumb and level, strongly secured against displacement and with built-in anchors. In masonry construction, set frames in advance of masonry work. Limit field-cutting, drilling and punching to minimum necessary.

B. Anchor metal frames in accordance with NAAMM Standards HMMA 861 and 862.

C. Anchor fire-door assemblies in accordance with NFPA 80.

D. Install doors after masonry work has been completed; accurately fit and adjust to work properly.

E. Maintain installation clearances and tolerances in accordance with NAAMM Standards HMMA 861 and 862.

F. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
1. Wire-brush welds and other repair areas to bright metal.
2. Apply galvanizing repair compound at rate of two ounces per square foot.

G. Touch-up shop applied primer as recommended by manufacturer for compatibility with finish paint system.

H. Application of finish hardware: Section 08710.

I. Glazing materials and installation: Section 08800.

3.02 CLEAN UP:

A. Upon completion of installation, clean surfaces of doors and frames as recommended by door manufacturer.
B. Remove from the site rubbish and debris caused by this work.

C. Leave areas surrounding openings in broom-clean condition.

END OF SECTION

SECTION 08305

ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing wall and ceiling access doors and frames, fire-rated wall access doors and frames, access hatches, tile covered access hatches and passenger emergency-egress hatches.

B. Work Specified Elsewhere:
1. Cast-In-Place Concrete: Section 03300.
2. Mortar, Grout and Masonry Accessories: Section 04050.
3. Brick Masonry: Section 04125.
4. Concrete Unit Masonry: Section 04220.
5. Structural Steel: Section 05120.
6. Roof Hatches: Section 07730.
7. Finish Hardware: Section 08710.
8. Tile: Section 09320.
9. Paver Tile: Section 09340.
10. Acoustical Panel Ceilings: Section 09511.
11. Field Painting: Section 09920.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data: For each type of door and frame indicated. Include construction details relative to materials, individual components and profiles, finishes, and fire ratings (if required) for access doors and frames.
2. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, hardware, fittings, fastenings, details, and attachments to other Work. Manufacturer's standard drawings may be submitted in lieu of Contractor prepared shop drawings if manufacturer's standard drawings show required details.
3. Samples: For each door face material, at least 3 by 5 inches in size, in specified finish.
4. Schedule: Provide complete door and frame schedule, including types, general locations, sizes, construction details, latching or locking provisions, and other data pertinent to installation.
5. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items with concealed framing, suspension systems, piping, ductwork, and other construction. Show the following:
   a. Method of attaching door frames to surrounding construction.
   b. Ceiling-mounted items including access doors and frames, lighting fixtures, diffusers, grilles, speakers, sprinklers, and special trim.
6. Certification:
   a. Certification from manufacturer of steel gratings verifying that gratings are capable of supporting loading as shown.
   b. Certified test reports of successful factory testing performed on passenger emergency-egress hatches. Certification of previous successful testing of hatches of same design furnished under similar Authority contracts acceptable in lieu of specified testing.
   c. Certification that welding personnel are currently qualified in accordance

with AWS D1.1.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: Standard Specifications for Highway Bridges: HS-20-44 Loading.
3. AGA: The Design and Fabrication of Galvanized Products.
4. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design
5. ASTM: A36, A53, A90, A123, A143, A153, A167, A193, A276, A307, A384, A413, A501, A588, A593, A633, A666, A780, A786, B221, B633, D1187, F594.
6. AWS: D1.1, D1.2, D1.3, D1.4.
7. FS; FF-B-588, FF-P-395, FF-S-325, RR-G-661, TT-P-664.
8. MS: MIL-P-21305.
9. NAAMM: Metal Finishes Manual for Architectural Metal Products
10. NFPA: 101 (Fire Exit Hardware), 252 (Standard Method of Fire Tests for Door Assemblies)
11. SSPC: SP 11, Paint 12.
12. UL: 10B (Fire Tests of Door Assemblies)

B. Source Limitations: Obtain doors and frames through one source from a single manufacturer.

C. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 that are identical to access door and frame assemblies tested for fire-test-response characteristics per the following test method and that are labeled and listed by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction:
1. [NFPA 252] [or] [UL 10B] for vertical access doors.

D. Size Variations: Obtain the Engineer's acceptance of manufacturer's standard-size units, which may vary slightly from sizes indicated.

E. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, “Structural Welding Code–Steel.”
2. AWS D1.2, “Structural Welding Code–Aluminum.”
3. AWS D1.3, “Structural Welding Code–Sheet Steel.”
4. AWS D1.4, “Structural Welding Code–Reinforcing Steel.”
5. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.

F. Passenger Emergency-Egress Hatches Meeting AASHTO HS-20-44 Loading:
1. Performance Requirements:
   a. Design exit hardware so that:
      1) Force of not more than 15 pounds on pull ring will actuate release bar and latches and outward force of not exceeding 30 pounds will open hatch.
      2) Force of not more than 50 pounds on pull ring will actuate release bar and latches when latched leaf is subjected to outward force of 250 pounds applied against latching edge adjacent to latch or to flush grip handle in direction in which latch opens.
   b. Provide one-inch minimum distance between bar and other door parts, when bar has traveled to fully open position.
   c. Provide sufficient supports on latch bars to prevent damage and misalignment.

d. Design and provide sufficient latch bar springs for proper operation.
e. Coordinate design with design-specialty applications which interface with hatch design
f. Make recommendations for specialty-design actions to be performed by other specialties.

2. Factory testing:
   a. Perform endurance testing in which hatch leaf is attached to frame assembly and, complete with exit hardware, is subjected to 1,000 opening-and-closing cycles. Hatch, including release mechanism, exit hardware and latches, to operate without failure and show no signs of excessive wear.
   b. Perform opening tests in which hatch leaf is subjected to the 15-pound test before and after endurance test and in which hatch leaf is subjected to 250-pound-outward-force test after endurance test. With spring scales, or by other approved means, test and record force required to open hatch. Opening force not to exceed 30 pounds for normal test and 50 pounds for 250-pound-outward-force test.
   c. Test data to be recorded and certified by the manufacturer.
   d. Notify the Authority at least 14 calendar days prior to each test.
3. Covers: Shall be reinforced to support a minimum live load of 300 psf (1464 kg/m2) with a maximum deflection of 1/150th of the span. Operation shall be smooth and easy with controlled operation throughout the entire arc of opening andclosing. Operation shall not be affected by temperature.
4. AASHTO-HS-20-44 load or higher load if required by the jurisdictional authority where the hatch is installed: Structural steel plate with load-carrier beams.

1.04 PROJECT CONDITIONS:

A. Field Measurements: Where doors and hatches are indicated to fit in walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
   1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products undamaged

B. Store products so as to prevent rust

C. Handle products so as to prevent damage.

D. After completion of factory testing, package and ship hatches as directed.

1.06 COORDINATION:

A. Verification: Determine specific locations and sizes for access doors needed to gain access to concealed equipment, and indicate on a schedule.

B. Concrete Work: Coordinate with concrete work so that frames are available for placing integrally with floor slabs or concrete walls unless frames are to be installed during related interior floor work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. General Requirements:
   1. Insofar as practicable, furnish similar products of a single manufacturer.
   2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.02 FERROUS METALS:

A. Structural Steel: Plates, shapes, bars and angles: ASTM A36.

B. Rolled-Steel Floor Plate: ASTM A786/A786M, raised pattern floor plates from rolled-steel floor plate, galvanized after fabrication, of thickness and in pattern indicated below:
   1. Thickness: Minimum 1/4 inch, unless otherwise shown or calculated.
   2. Pattern: No. 2, or as selected from manufacturer's standard patterns; flat back.

C. Load-carrier beams: ASTM A588.

D. Structural Tubing: ASTM A501.

E. Steel Pipe: ASTM A53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads. Galvanized unless otherwise shown or specified.

F. Pipe Sleeves and Pipe Fittings: ASTM A53. Galvanized unless otherwise shown or specified.

G. Stainless Steel Sheets, Strips, Plates, Shapes, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.

H. Stainless Steel Bars and Shapes: ASTM A276, Type 304. Type 316L for corrosive environment.

I. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless steel eyes, spring-loaded catches and mounting components.

J. Grating: Steel, bar and crossbar type shown, hot-dipped galvanized after fabrication and sizing, FS RR-G-661, Type 1, Class 1 or 2.

2.03 ALUMINUM:

A. Aluminum Extrusions: ASTM B221, Alloy 6063.

B. Aluminum-Alloy Rolled Tread Plate: ASTM B 632, alloy 6061.

2.04 FASTENERS:

A. General: Provide Type 302 or 316 stainless steel fasteners for exterior use and zinc-plated fasteners complying with ASTM B633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.

B. Screws: Material, type and size to suit purpose; steel, except stainless., cadmium-plated.

1. Stainless steel, ASTM A193, Alloy S30400.

C. Machine Bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
   1. Carbon steel: ASTM A307, Grade B, galvanized.
   2. Stainless steel: ASTM A193, Class 1A.

D. Toggle bolt: FS FF-B-588.

E. Drive stud: FS FF-S-325, Group 6.

F. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.

G. Screw anchors: Lead or plastic for wood or metal screws.

H. Anchor bolt sleeve: Corrugated high-density polyethylene plastic.

I. Powder actuated: FS FF-P-395.

J. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488, conducted by a qualified independent testing agency.
   1. Material: Alloy Group 1 or 2 stainless steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

2.05 CONCRETE AND GROUT:

A. Nonshrink Grout: Section 04050.

B. Surface hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

2.06 COATINGS:

A. Shop Primer for Ferrous Metals: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.

B. Galvanizing (zinc-coating by hot-dipped process): ASTM A90, ASTM A123, or ASTM A143, ASTM A153 or ASTM A384, as applicable.

C. Zinc-rich paint: MS MIL-P-21305.

D. Electro deposited zinc coating: ASTM B633.

E. Galvanizing Repair Compound: Stick form, melting point 600-degree F to 650-degree F, GALVABAR or equal.

F. Bituminous Coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.07 FABRICATION, GENERAL:

A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Provide access door assemblies manufactured as integral units ready for installation.

C. Fabricate and prepare products required to be galvanized in accordance with recommendations of AGA.

D. Provide material that is free from mill scale, flake rust and mill pitting.

E. Cut, reinforce, drill and tap metal fabrications as indicated to receive finish hardware, screws, and similar items. Provide plates welded on for mounting hardware.

F. Sheer and punch metals cleanly and accurately. Remove burrs.

G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners whenever possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

H. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

I. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

J. Where miscellaneous access openings, with exception of gratings, occur in finished floor areas, include stainless steel edge rims of depth to accommodate floor finishing materials.

K. Welding corners and seams continuously to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

L. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.

M. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.

N. Remove sharp or rough areas on exposed traffic surfaces.

O. Painting: Shop paint (prime) before shipment. Phosphatize galvanized surfaces before priming.

2.08 WALL AND CEILING ACCESS DOORS AND FRAMES:

A. Access Doors: Steel, baked-enamel prime coat; 12-inches square, minimum size.
   1. Wall-mounted, sheet steel type: Sizes under four square feet.
      a. Door:
         1) Fixed: 1/4-inch steel plate screwed to frame 18 inches on centers maximum, with flathead, countersunk, tap screws.
         2) Operable: Equipped with spring hinges and lockset conforming to requirements of Section 08710; locks keyed into group with mechanical rooms.
      b. Frame: Structural steel shapes and corners mitered and welded. Strap anchors places not more than 18 inches on centers and extending 18 inches minimum into masonry or concrete.
   2. Wall-mounted, hollow metal type: Size over four square feet.
      a. Door and frame: Conform to the requirements of Section 08110; galvanized in exterior walls.
      b. Hardware: Equipped with spring hinges and lockset conforming to requirements of Section 08710; locks keyed into group with mechanical rooms.
      c. Fire rated: UL 1-1/2 hour B-Label, with labeled hardware.
   3. Ceiling mounted: Galvanized steel, door and frame 16-gauge minimum; continuous piano hinge; with sleeve and plastic grommet for screwdriver from the room side; for gypsum board ceiling.
      a. Door and frame: Flush with ceiling surface; flush metal door fitting neatly into the frame.
      b. Size and locations: As required to access equipment indicated or as shown.
      c. Insulation: Provide upper side of doors with one-inch thick mineral fiberboard permanently cemented in place.
      d. Manufactured by the C. M. Walsh Company of Boston, Massachusetts, or equal.
   4. Wall or ceiling mounted in plaster walls or ceilings: Size 16 inches square.
      a. Flush door panel mounted to frame on concealed spring hinges opening to 175 degrees.
      b. Fire rated: UL 1-1/2 hour B-Label, with key operated flush lock.
      c. Manufactured by MILCOR, K-access door or equal.

2.09 ACCESS HATCH, TYPE A:

A. Fabricated by a manufacturer regularly engaged in the production of access hatches; and designed to meet the requirements of AASHTO-HS-20-44 load or higher load if required by the jurisdictional authority where the hatch is installed.

B. Door:
   1. Grating: Steel, ASTM A36.
   2. Side Plate: Floor plate, diamond pattern, flat back.
   3. Bearing bars: 2-1/2 inches by 1/4 inch at 13/16-inch on centers and cross bars at four inches on centers.

C. Frame: Structural steel angle framed on three sides, formed steel plate on the hinge side.

D. Ferrous-metal components: Galvanized after fabrication.

E. Hardware:
   1. Hinges: Forged brass with stainless steel pins.
   2. Lifting mechanism: Stainless steel compression-spring mechanism balancing door leaves through entire arc acting as check to downward motion. Force necessary to open the hatch not to exceed 50 pounds.

3. Hold-open devices: Automatic, 90-degree hold-open arms with vinyl-covered release handles.
4. Locking devices: Snap locks with handles on the underside and removable key handles on top side. Include removable plugs for concealing key holes.

2.10 PASSENGER EMERGENCY-EGRESS HATCH:

A. Fabricated by a manufacturer regularly engaged in the production of access hatches; and designed to meet the following requirements:

B. Door leaves: Fabricated in accordance with approved shop drawings.
1. 250 pounds per-square-foot loading: Rolled Steel Floor plate, diamond pattern, flat back. Galvanized after fabrication.

C. Frame: 1/4-inch structural steel with formed gutters with drainage couplings. Frames welded to eight-inch supporting channels on four sides with full flange around perimeter. Galvanized after fabrication.

D. Drain Coupling: Provide a 1-1/2" drain coupling located in the right front corner of the channel frame (note: can be placed at a different location if directed by the Engineer).

E. Hardware:
1. Hinges: Forged brass or Type 316 stainless steel. Hinge pins of stainless steel. Each hinge equipped with two pressure-lubrication fittings, Lincoln No. 5012, or equal.
2. Lifting Mechanism: Stainless steel compression-spring mechanism balancing door leaves through entire arc acting as check to downward motion. Force necessary to open the hatch when applied to inner edge of exit release bar not to exceed 30 pounds. Manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a check in retarding downward motion of the cover when closing. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4" gusset support plate.
3. Hold-open devices: Covers shall be equipped with a hold open arm which automatically locks the covers in the open position.
4. Locking devices:
   a. Interior: Stainless steel panic bar fabricated and installed to meet NFPA 101 requirements.
   b. Exterior: A removable exterior turn/lift handle with a spring loaded ball detent shall be provided to open the leaf and the latch release shall be protected by a flush, gasketed, removable screw plug.
   c. Miscellaneous: Flush grip handles, pull rings with removable caps, handrails on leaves and guard chains of type standard with manufacturer.

2.11 TILE-COVERED FLOOR HATCH:

A. General: Commercially manufactured to support a uniformly distributed live load of 150 psf and a maximum deflection of 1/150 of the span. Custom sized heavy duty aluminum frame and cover with aluminum or brass exposed edges, and complete with reinforcing, support beams (where necessary), and related accessories.

B. Aluminum Frames and Covers: Extruded aluminum, ASTM B 221, alloy 6063-T6, with

mitered and keyed corners and factory coated with zinc chromate primer or manufacturer's standard protective paint where surfaces will be in contact with concrete.

1. Exposed Edge Finishes: Mill finish, No. 385 alloy bronze.
2. Cover Reinforcing: ASTM A 185 (mesh) or ASTM A 615 (bars), factory engineered to meet design load requirements for medium and heavy duty applications.

C. Steel Support Beams: ASTM A 36, factory engineered to meet design load requirements where maximum spans for single cover are exceeded and elsewhere when required. 1. Furnish steel beam pocket and bearing plate for support beams

D. Hardware:
1. Lifting/Locking Device: Lifting blocks (one each corner typically) secured to hatch cover and fitted with threaded bolt
   a. Furnish threaded handle for lifting, with integral hex head drive for removing securing bolt (for covers equipped with double seals) or blanking bolt (for non-sealed covers).
2. Seals: Continuous EPDM perimeter seal.
3. Concrete Fill: Section 0330

E. Fabrication:
1. Shop fabricate floor access hatches and covers in sizes and configurations shown for single unit pit access, or multiple unit trench access.
2. Sizes (Single Unit Maximum): 48 inches square (clear opening).
   a. Where size requirements exceed those shown, multiple covers can be joined together to obtain the desired sizes.
   b. Where very large covers are required, a small inspection cover may be integrated into the large cover for convenience.
3. Sizes (Multiple Units Maximum): 36 inches square (clear opening).
4. Furnish reinforcement assembly loose for field positioning.
5. All aluminum surfaces in contact with concrete shall receive a factory applied primer or protective paint.
6. Dissimilar metals shall be protected against electrolytic action.

2.12 FINISHES:

A. General:
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Finish metal fabrications after assembly.
3. Galvanize ferrous metal unless other finish is shown or specified.

B. Galvanizing:
1. Clean ferrous metal throughly before applying zinc coating.
2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than two ounces per-square-foot.

C. Shop Paint:
1. Ferrous metal throughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
2. Zinc yellow iron-oxide primer or red-lead based primer applied so as to thoroughly cover surfaces without leaving runs or sags

D. Stainless Steel: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of

cross scratches. Run grain with long dimension of each piece.

E. Aluminum: AA-M10 (Mechanical Finish: as fabricated, unspecified).

PART 3 - EXECUTION

3.01 PREPARATION:

A. Advise installers of other work about specific requirements relating to access door and floor door installation, including sizes of openings to receive access door and frame, as well as locations of supports, inserts, and anchoring devices.

B. Examine the substrates and conditions under which the work is to be performed, and notify the General Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the installation until unsatisfactory conditions have been corrected.

C. Remove foreign substances from surfaces to receive metal items.

D. Protect surrounding surfaces from damage while performing the work of this section.

3.02 INSTALLATION, GENERAL:

A. Coordinate placement of doors with the work of other trades

B. Comply with manufacturer's written instructions for installing all access doors and hatches.

C. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.

D. Cutting, Fitting and Placement: Perform cutting, drilling, and fitting required for installing doors and hatches. Set frames, doors and hatches accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured form established lines and levels.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry or similar construction.

F. Provide anchors and inserts in sufficient numbers for proper fastening of doors and hatches.

G. Provide bar anchors with turned ends extending six inches minimum into concrete and 12 inches minimum into masonry. Lay anchors flat in masonry joints.

H. Embed anchors accurately in concrete to permit aligning door in proper position.

I. For fabricated items, use fastenings and anchors of size and type shown on approved shop drawings or manufacturer’s standard drawings.

3.03 INSTALLING PASSENGER EMERGENCY-EGRESS HATCH:

A. Lift hatches by means of slings attached at four corners of each hatch frame.

B. Set hatch in framed opening; shim as necessary to ensure even support of hatch and alignment with adjoining work and in accordance with manufacturer’s recommendations. Shim pattern, as shown

C. After shimming, ensure hatch is not racked and weld in place as shown.

D. After welding is completed, repair damaged zinc-coating and abraded shop coatings.

E. Field-weld steel inserts to hatch frame and opening frame at hatch hinge points and coat completely with galvanizing repair compound at rate of two ounces per-square-foot.

F. Fill space between hatch and frame and framed opening with nonshrink grout.

G. Install 1-1/2 inch steel, Schedule 40, piping from hatch frame drain to floor drain, of if no drain, to floor. Piping not to encroach on egress pathway or headroom clearance (six-feet,eight-inches, minimum). Drain not to discharge into egress pathway.

3.04 TILE-COVERED ACCESS HATCHES:

A. Set aluminum frames in recess, level and in proper relationship to adjacent finished flooring. For multiple covers and where maximum span for single covers is exceeded, install beam pockets and set support beams on base plates grouted to required heights. Grout frames solid with Portland cement concrete.

B. Place cover in frame properly aligned. Clip reinforcement assembly into proper position and fill cover with Portland cement concrete to height necessary to receive scheduled finish flooring material. Hand trowel to smooth dense surface.

3.05 PAINTING AND REPAIRING COATED SURFACES:

A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finish work, except items encased in concrete.

B. Where shop coat is abraded or burned by welding, clean and touch-up.

C. Touch-up primed surfaces with same material as coating.

D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.

E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
1. Wire brush areas to be coated to bright metal.
2. Apply galvanizing repair compound at rate of two ounces per-square-foot.

3.06 FIELD QUALITY CONTROL OF PASSENGER EMERGENCY-EGRESS HATCH:

A. Field Testing of Passenger Emergency-Egress Hatch:
1. Upon completion of installation of passenger emergency-egress hatch, verify with spring scales that each leaf of each access hatch will open when force of 30 pounds or less is applied at inner end of exit release bar.
2. Operate leaf no less than three times. Record opening force required each time. If adjustments are necessary to achieve specified results, repeat the test.
3. Perform field tests in the presence of the Engineer.
4. At the time of final inspection for substantial completion, repeat field tests as specified.
5. If hatch fails field tests, make necessary adjustments until it operates as specified.
6. During the life of the Contract, check operation of hatch leaves at periods not

exceeding 90 days. Lubricate moving parts and check for proper operation.

3.07 ADJUSTING AND CLEANING:

A. Adjust doors and hardware after installation for proper operation.

B. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.

C. Tile-Covered Access Hatches: If necessary for alignment after finish flooring is installed, exposed edges of frame and cover may be ground to remove up to 1/8 inch and provide flush surface.

END OF SECTION

SECTION 08710

FINISH HARDWARE

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing finish hardware.

B. Related Work Specified Elsewhere:
1. Access Doors and Frames including locks and cylinders: Section 08305.
2. Overhead Coiling Doors: Section *08331*.
3. Overhead Coiling Grilles: Section 08334.
4. Cremone bolt to receive lock and chain provided under this section: Section 02877.
5. Hollow Metal Doors and Frames: Section 08110.
6. Aluminum Entrances and Storefronts: Section 08410.
7. Metal Concave Mandoors: Section 08481.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulation of the jurisdictional authorities.
2. ANSI/BHMA: A156-Series Standards for Builders Hardware.
3. ASTM: A413
4. FS: *T*T-S-001657.
5. ADA: ADAAG.
6. NFPA: 80, *101, 130.*
7. DHI: Recommended Locations for Builders Hardware for Standard Steel Doors and Frames, Recommended Locations for Builders Hardware for Custom Steel Doors and Frames.

B. Hardware Supplier Qualifications: A recognized architectural finish hardware supplier, with warehousing facilities in the Project's vicinity, that has a record of successful in-service performance for supplying finish hardware similar in quantity, type, and quality to that indicated for this Project and that employs an experienced architectural hardware consultant (AHC) who is available to the Engineer and Contractor, at reasonable times during the course of the Work for consultation.
1. Require supplier to have his AHC develop the hardware schedule.
2. Require supplier's AHC to meet with the Engineer to discuss and finalize lock-functions and keying requirements.

C. Fire-Rated Openings: Provide hardware for fire-rated openings that complies with NFPA 80 and requirements of authorities having jurisdiction. Provide only items of hardware that are listed and are identical to products tested by UL, Warnock Hersey, FM, or other testing and inspecting organization acceptable to authorities having jurisdiction for use on types and sizes of doors indicated in compliance with requirements of fire-rated door and door frame labels.
1. Equip labeled doors with hinges of steel or stainless steel base metal, closers, and automatic latching devices in addition to the hardware requirements in the specified hardware sets.
2. If a conflict appears between this paragraph and the hardware sets scheduled, the requirements of this paragraph govern.

D. Americans With Disabilities Act (ADA): Comply with the ADA Accessibility Guidelines (ADAAG).

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings:
   1. Product Data: Manufacturers' technical literature and catalog cuts, edited as necessary to indicate each item of hardware, model, selected options, finish, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements. Make coordinated submittals packages complete with all supporting data.
   2. Hardware Schedule: Hardware schedule coordinated with doors, frames, gates and related work to ensure proper size, thickness, hand, function, design and finish of hardware. Base Hardware Schedule on hardware sets indicated in PART 3 of this section. Indicate complete designations of each item required for each door or opening, including the following information:
      a. Explanation of each abbreviation, symbol, and code contained in hardware schedule. Schedules with unidentified notations will be rejected without review.
      b. Door and frame number, size, and materials.
      c. Type, style, function, size, and finish of each hardware item. Include lockset functions, angle of closer operation, lever and handle designs, lengths of flush bolts, types of stops, sizes of armor and kick plates, and other such data.
      d. Name and manufacturer of each item.
      e. Fastenings and other pertinent information.
      f. Location of each hardware set cross-referenced to indications on Drawings, both on floor plans and in door schedule.
      g. Mounting locations for hardware.
      h. Keying information.
   3. Submittal sequence: Submit hardware schedule at earliest possible date particularly where acceptance of hardware schedule must precede fabrication of other work that is critical in the Project construction schedule. Include with hardware schedule the product data, samples, shop drawings of work affected by finish hardware, and other information essential to a coordinated review of hardware schedule.
   4. Templates: Transmit hardware templates directly to trades fabricating related work specified to be prepared for the installation of finish hardware under this section. Submit record copy of these transmittals to the Engineer.
   5. Coordinating hardware preparation by other trades: Check shop drawings of other trades to ensure that correct provisions from transmitted templates are made for locating and installing finish hardware to comply with indicated requirements.

B. Samples:
   1. Finishes: Two, minimum four-inch squares *of* each finish to be furnished. Submit with shop drawings.
   2. Hardware units: Each type of exposed hardware unit in approved finish and tagged with full description for coordination with hardware schedule. Submit unit samples prior to submission of final hardware schedule.
      a. When requested, samples will be returned to the supplier. Accepted units that remain undamaged through the submittal, review, and field-comparison process may, after final check of operation, be used in the Work, within limitations of keying coordination requirements.

b. Submit the following:
   1) One sample of a lockset including, trim, escutcheon, strike box, lever, cylinder, and key.
   2) One sample of hinge.
   3) One sample of each miscellaneous item of finish hardware.
   4) Provide finishes so that color and surface finish or polish of various items of the same designated finish match throughout the work. Hardware with non-matching finishes will be rejected.

c. The Authority reserves the right to require samples of each specific item to be furnished.

C. Certification.

D. Documentation:
   1. Construction keying schedule.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to jobsite in original unopened packages, clearly labeled with manufacturer's name, brand, specification identification data and identification as shown on approved hardware schedule.

B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.05 MAINTENANCE TOOLS AND INSTRUCTIONS:

A. Furnish a complete set of specialized tools and maintenance instructions as needed for the Authority's continued adjustment, maintenance, removal and replacement of hardware.

PART 2 - PRODUCTS

2.01 HARDWARE TYPES:

A. General:
   1. Hardware grade: Provide only Grade 1 hardware in accordance with ANSI/BHMA A156-Series Standards and with the additional requirements specified in this section, except where otherwise specified or approved in writing by the Engineer for each specific door number.
   2. Fire-rated hardware: Where applied to fire-rated labeled doors and frames, provide fire-rated listed hardware, tested by a fire-rating testing agency acceptable to authorities having jurisdiction.
   3. Finishes: Finish designations are ANSI/BHMA A156.18 standards and are subject to approval for color, texture and appearance.
      a. Finish 630 (Formerly US 32D): Except where otherwise indicated, provide finish 630, satin-polish stainless steel on stainless steel base metal, matching sample on file with the Engineer.
      b. Finish 626 (Formerly US 26D): Where indicated, provide finish 626, satin-polish chromium plated over nickel on brass or bronze base metal, matching finish 630 as specified above.
      c. Finish 628 (Formerly US 28): Where indicated, provide finish 628, satin-polish aluminum clear anodized over aluminum base metal.

d. Finish 652 (Formerly US 26D): Where indicated, provide finish 652, satin-polish chromium plated over nickel on steel base metal, matching finish 630 as specified above.
e. Finish 719 (Formerly US27): Mill finish aluminum uncoated.
f. Finish 613 (Formerly US10B): Where indicated, provide finish 613, satin-finish statuary bronze.
g. Finish 630 may be substituted for Finish 626 or Finish 652 at no additional cost to the Authority.

4. Single Source: Obtain each type of hardware from a single manufacturer.

B. Hinges: ANSI/BHMA A156.1, full mortise butt hinges, anti-friction bearings, button tips (not flush), unless otherwise specified for each specific door number. Extruded butts may be used in lieu of wrought butts.

1. Quantity required per door leaf:
   a. Doors 61 inches to 90 inches in height: 1-1/2 pairs.
   b. Doors 91 inches to 120 inches in height: Two pairs.
2. Types:
   a. Exterior doors, doors from public passageways, and doors to wet areas such as showers: Stainless steel butts, Type A5111, finish 630.
   b. Interior, non-public doors: Steel butts, Type A811*1* (Grade *1*), Finish 652.
   c. Doors with reverse-bevel swing (out-swinging) having locks: Fit butts with non-removable pins effective when door is in closed position.

C. Locksets:

D. Hollow metal doors: ANSI/BHMA A156.13, full mortise, adjustable armored front, 3/4-inch-throw anti-friction latchbolt, one-inch-throw stainless steel deadbolt, Finish 630, Function as scheduled.

1. Trim design:
   a. Cast lever handles, recurving to within 1/2-inch of door face, equal in appearance and dimensions to one of the following unless otherwise scheduled:

Series	Design	Producer
ML2200 Series	Newport NSA	Corbin/Russwin
8200 Series	KD rose, L lever	Sargent
8700 Series	PB lever, YK rose	Yale

   b. Finish: 630 unless otherwise scheduled.
   c. Roses: Concealed screw or screwless, 2-1/4 inch diameter.
   d. Cylinder trim: Equip with flush or security-beveled solid cylinder collar as appropriate for flush or projecting cylinder.
2. Aluminum doors in Yard Buildings:
   a. Finish: 630 unless otherwise scheduled.

E. Cylinders and Keying for all doors except aluminum doors in Parking Structures: Match the Authority's existing keying and interchangeable core system as follows and at no additional cost to the Authority.

1. Cylinders: Finish 630.
   a. For locksets: ANSI/BHMA A156.5, interchangeable-core type, designed to accept the Authority's existing Russwin Recore System. One core furnished for each lock, stamped with visual key control.

b. High security: Interlocking-pin type, Emhart High-Security Locking System or equal.
c. Construction cores: Provide construction cylinders until final cylinders and keying is approved and installed.

2. Keys and keying:
a. Keys: Stamped with the inscription TRANSIT AUTHORITY - DO NOT DUPLICATE and with visual key-control data.
b. Quantity: Three keys for each core plus blanks equal to 10-percent of total keys furnished.

3. Key tags and holders: ANSI/BHMA A156.5, inscribed with key-change number and key-control symbol.

F. Push Plates and Door Pulls: ANSI/BHMA A156.6, Finish 630, with the following additional requirements:
1. Push plate: 3/16 inch by 10 inches by 20 inches unless otherwise shown, with edges beveled.
2. Door pull: 3/4-inch round bar, eight inches center-to-center, concealed fasteners; escutcheon plate same as push plate.

G. Door Closers: ANSI/BHMA A156.4, Type C02xx1 (xx - indicates top-of-door-mounted, on interior side), Finish 630.
1. Surface-mounted.
2. Sweep period: Adjusted so that from an open position of 70 degrees, the door will take at least three seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.
3. Cover plate: Full metal cover, Finish 630.
4. Parallel arms and drop brackets: Provide as necessary for mounting on interior side unless otherwise noted. Where hold-open feature is specified for closers, use type that permits doors to open 140 degrees, other conditions permitting.
5. Maximum force for pushing or pulling open a door with closer (measured with a push-pull scale applied perpendicular to the door at the door opener or 30 inches from the hinged side, whichever is farther from the hinge):
a. Fire doors: Minimum opening force allowable by the jurisdictional authorities.
b. Interior hinged doors: 5 lbf.

H. Stops:
1. Overhead-type: ANSI/BHMA A156.8, Type C54511 holder/stop; holder deactivated on labeled doors, Finish 630.
2. Wall-type: ANSI/BHMA A156.16, Type *L02101*, with vandal-resistant concealed fasteners, Finish 630. Use floor-type where wall-type is not practicable.
3. Floor-type: ANSI/BHMA A156.16, Type L02141 or L02161 as necessary, with matching extender if necessary to properly engage door bottom, Finish 630.

I. Flush Extension Bolts: ANSI/BHMA A156.8, Type L04081, Finish 630.
1. Dustproof strikes, Type L04021, provided for bolts located at bottom of door leaf, except where metal thresholds are specified. Cut opening to suit bolt.
2. Operating mechanism located approximately six feet from floor for top bolts and approximately 12 inches from floor for bottom bolts.
3. Bolts located in edge of inactive leaf of pair of doors.
4. Automatic Flush Bolts: Listed for 1-1/2 hour, B-labeled, Finish 630; Ives No. 559 or equal with strikes; with coordinator where recommended by manufacturer.

J. Silencers: ANSI/BHMA A156.16, Type L03011. Provide silencers for each door:
1. Three for each single door.

2. Two for each pair of doors.

K. Exit Devices: ANSI/BHMA A156.3; complying with NFPA 80, listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction; lever trim as required for locksets; Finish 630.
1. Single door: Function F03 (mortise); latch bolt by push on crossbar inside and by key from outside; operation from outside is by lever.
2. Double door: Active leaf Function F03 as above, inactive leaf (manual flush bolts) without outside trim.
3. Maximum pushing force to operate exit device:
   a. Fire doors: Minimum opening force allowable by the jurisdictional authorities.
   b. Interior hinged doors: 5 lbf.
4. Coordinators: ANSI/BHMA A156.3.

L. Metal Thresholds: ANSI/BHMA A156.21; profiles as shown for each location; ADA compliant; metal thickness 0.125 inch; maximum height 5/16"; with countersunk matching screws.
1. Public passageways and mezzanines: Finish 630, stainless steel with abrasive finish or Finish 613, satin-finish statuary bronze.
2. Other locations: Finish 719, mill finish aluminum with grooves.

M. Weather Stripping */Smoke Seals*: ANSI/BHMA A156.22, Finish 628 (satin aluminum clear anodized) with stainless steel sheet-metal screws and as follows:
1. Head and jamb: Head and jamb type, stop-applied; National Guard *A626* or equal. Provide nylon brush gasketing or equal.
2. Sill: Drip strip at sill; National Guard 15 or equal.
3. Sweep: Door sweep type, surface mounted at bottom of door; National Guard D608 nylon brush gasketing or equal. Provide sweep in addition to drip strip where scheduled.
4. Astragals: Provide nylon brush overlapping type: National Guard 600 or equal.

N. Chain: ASTM A413, Class PT, case-hardened, carbon-steel security chain, 3/8-inch diameter.

O. Padlock: Interchangeable-core type padlock, designed to accept the Authority's existing Russwin Recore System.
1. One core furnished for each lock, stamped with visual key control; with two keys, keyed and master-keyed as directed.
2. Body: Solid extruded brass.
3. Five-pin tumblers.
4. Shackle: Hardened steel, zinc-plated, 1-3/4 inch opening height, self-locking spring-type.

P. Deadlock: ANSI/BHMA A156.5 mortise dead lock, Grade 2 (1/2-inch minimum throw) with interchangeable-core cylinder; operation as scheduled.

Q. Authority-Furnished Property:
1. Cross-bar lock: High-security locking bar with surface-mounted keepers, inside knob and high-security cylinder.

2.02 FASTENINGS:

A. Provide hardware complete with screws, through-bolts and other fasteners of suitable type for secure anchorage to construction materials.

B. Screws, through-bolts and other fasteners having spanner-type heads: As approved.

C. Provide fasteners that harmonize in material, color and texture with finished appearance of hardware items.

D. Provide concealed fastenings with door pull, flush pulls, wall door stops and other such items.

E. Provide spanner-head through-bolts and hex bolts as applicable for surface-mounted hardware.

F. Sheet-metal screws and self-tapping screws are prohibited except where specified.

2.03 TEMPLATES:

A. Furnish templates of hardware to other trades, so that doors, frames and gates can be cut, reinforced and otherwise prepared in the shop for installation of finish hardware.

2.04 THRESHOLD SEALANT:

A. Butyl: Polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum 75 percent solids, non-sag consistency, tack-free time of 24 hours or less, paintable, non-staining, and complying with FS TT-S-001657.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. General:
1. Coordinate work of this section with work of other trades.
2. Install each hardware item in compliance with the manufacturer's instructions and recommendations.
3. Apply finish hardware in a neat and workmanlike manner. Set units level, plumb, and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.
4. Cut mortises neat, clean and of proper net size. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.
5. Where cutting and fitting is required to install hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation or application of surface protection with finishing work specified in other sections. Do not install surface-mounted items until finishes have been completed on the substrates involved.
6. Provide keying in accordance with keying schedule prepared by and for the Contractor in accordance with the Authority's keying system. Deliver keying schedule and keys to the Engineer prior to final acceptance.

B. Mounting Heights: Mount hardware units at heights indicated in the following publications, except as specifically indicated or required to comply with governing regulations and except as otherwise directed by the Engineer:
1. Recommended Locations for Builders Hardware for Standard Steel Doors and Frames by DHI.
2. Recommended Locations for Builders Hardware for Custom Steel Doors and Frames by DHI.
3. ADA Accessibility Guidelines (ADAAG).

C. Exterior Thresholds: Set thresholds for exterior doors in full bed of specified butyl sealant.

D. Weatherstripping */Smoke Seals*: Install weatherstripping around entire perimeter of door frame to form a complete seal and in accordance with manufacturers instructions.
1. Position and install head and jamb weatherstripping so that door closes snugly against seal but does not inhibit latching of lockset.
2. Position and install sill weatherstripping to seal snugly against threshold without inhibiting latching of lockset.
3. Note that at fire-rated doors, lockset is to latch by closer operation only, without manual assistance.

E. Adjustment: Adjust hardware to operate as designed and replace hardware that is missing, scratched, marred or otherwise damaged.
1. Adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate freely and smoothly or as intended for the application made.
2. Where door hardware is installed more than one month prior to acceptance or occupancy of a space or area, return to the installation during the week prior to acceptance or occupancy and make final check and adjustment of hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.
3. Clean adjacent surfaces soiled by hardware installation.

F. Instruction: At a time prescribed by the Engineer, have the hardware installer or knowledgeable operating-hardware-manufacturers' representatives instruct the Authority's personnel in the proper adjustment and maintenance of hardware and hardware finishes.

3.02 CLEAN-UP:

A. Remove from the site rubbish and debris caused by this work.

B. Leave areas surrounding doors in broom-clean condition.

3.03 HARDWARE SETS:

A. Hardware Sets:
1. Provide hardware sets in accordance with door schedule and the following set schedule.
2. Provide the number of pairs of butt hinges in accordance with previously specified requirements.
3. Designations used to describe hardware items by using a manufacturer's product name and number are for the purpose of describing a general level of quality and function. Products that are equal, complying with the requirements specified in this section may be used.

SET NO. 1

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F09
1 Each	Door Closer
1 Each	Wall-Type Stop
1 Each	Metal Threshold

SET NO. 2

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
1 Each	Door Closer
1 Each	Wall-Type Stop

SET NO. 3

Quantity	Hardware
As Necessary	Lock Cylinders *

* Provide proper cam to engage lock mechanism by other trade.

SET NO. 4

Quantity	Hardware
1 Each	Deadlock, E06082

SET NO. 5

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Latchset, Function F01
1 Each	Door Closer
1 Each	Wall-Type Stop

SET NO. 6

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Exit Device, Function F03
1 Each	Door Closer
1 Each	Wall-Type Stop

SET NO. 7

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F13
1 Each	Door Closer with Hold-Open
1 Each	Wall-Type Stop
1 Each	Cross-Bar Lock

SET NO. 8

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
2 Each	Door Closer
2 Each	Wall-Type or Floor-Type Stop
2 Each	Automatic Flush Bolt
1 Each	Coordinator

SET NO. 9

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
2 Each	Door Closer
2 Each	Overhead-Type Stop
1 Each	Metal Threshold
2 Each	Automatic Flush Bolt
1 Each	Coordinator
1 Set	Weatherstripping

SET NO. 10

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
2 Each	Door Pulls
2 Each	Door Closer with Hold-Open
2 Each	Wall-Type or Floor-Type Stop, As Necessary

SET NO. 11

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F09
2 Each	Door Closer
1 Each	Wall-Type Stop
1 Each	Metal Threshold
2 Each	Automatic Flush Bolt
1 Each	Coordinator

SET NO. 12

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
1 Each	Door Closer
1 Each	Overhead-Type Stop
1 Each	Metal Threshold
1 Set	Weatherstripping

SET NO. 13

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F14
1 Each	Door Closer
1 Each	Overhead-Type Stop
1 Each	Metal Threshold
1 Set	Weatherstripping

END OF SECTION

SECTION 08800

GLASS AND GLAZING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing glass and glazing (sealing) of glass areas.

B. Related Work Specified Elsewhere:
1. Elevators: Division 14. *1
2. Granite edge: Section 04415.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ANSI: Z97.1.
3. ASTM: C509, C542, C864, C920, C1036, C1048, C1172, C1281, D635, D1044, D1925, E774, E1300.
4. CPSC: 16 CFR 1201, Category II.
5. UL: 9, 10B.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Samples:
   a. Three each of the following:
      1) Glass and safety plastic: 12 inches square, each material and type.
      2) Cast glass lens.
      3) Glazing compound: Pint containers.
      4) Setting blocks and edge blocks.
      5) Sealant: Cured color samples.
         a) Sealant for sealing platform granite edge glass lenses: Clear silicone sealant,, one six-inch long bead.
      6) Gasket material: 12 inches long.
2. Certification:
   a. When glass is not cut to size by manufacturer and is furnished unlabeled from local stock, submit certification stating location to be installed, quality, thickness, type and manufacturer of each unit of glass furnished.
   b. All tempered safety and laminated tempered safety glass to be permanently marked with the name or trademark of the manufacturer and designation of the applicable safety glazing standard.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to the jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and rating as applicable. Deliver glass with each light bearing manufacturer's label showing strength, grade, thickness, type, quality and safety marking. Do not remove labels from glass until it has been set and inspected.

B. Store products in approved dry area; protect from contact with soil and from exposure to the elements.

C. Handle products to prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not install glass when the ambient temperature is below 40F or expected to fall below 40F, unless otherwise approved.
2. Do not apply glazing materials to unprotected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Glass:
1. Plate glass: ASTM C1036, Type I (transparent glass, flat), Class 1 (clear), Quality q3.
2. Safety glass: CPSC 16 CFR 1201, Category II and ANSI Z97.1 and as follows:
   a. Tempered: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated surfaces), Type I (transparent glass, flat), Class 1 (clear), Quality q3; 1/4-inch thick unless otherwise shown.
   b. Laminated: ASTM C1172, Kind LT(fully tempered), 0.060-inch thick polyvinyl-butyral (PVB) interlayer factory-laminated between two pieces of tempered safety glass with protective edgecoat on the assembly to prevent contact of interlayer with water or joint materials; edgecoat such as Edgeseal by PPG, special polyurethane seal on Solaflex glazing by Monsanto, Sommer Macca Urethane E#2 by SX Chemical Company, or equal.
   c. Laminated fritted glass:
      1) Construction: ASTM C1172, Kind LT, Laminated glass consisting of two pieces of fully tempered clear glass with one of the following fritting methods to make the laminated assembly translucent but not transparent:
         a) A hue-white fritted surface permanently fused onto the laminated surface of one piece of glass with a clear 0.60-inch polyvinyl-butyral (PVB) interlayer between.
         b) Two pieces of clear glass with a hue-white 0.30-inch PVB interlayer (fritting) sandwiched between two 0.15-inch clear PVB interlayers.
      2) Opacity: 80 percent coverage of translucent white fritting. Pattern of fritting to be selected by the Engineer from manufacturer's whole range of fritting patterns.
      3) Provide protective edgecoat to prevent contact of interlayers with water or joint materials.
3. Wired: ASTM C1036, Type II (wired), Class 1 (translucent), Form 1 (wired, polished both sides), Quality q8; Mesh m1 (diamond), unless otherwise shown.
4. Fire-rated glass (without wire): CPSC 16 CFR 1201 and ANSI Z97.1; fire-rated clear glass without wire; polished both sides.
   a. Rating: 45 minutes or as shown, tested in accordance with UL9 (door assemblies) and UL10B (window assemblies).
   b. Label: Each piece of glass bearing UL label for fire resistance.

c. Thickness: As necessary to achieve the required fire rating; thickness coordinated with submitted shop drawings for the related doors and windows.

d. Sources: Subject to meeting the requirements, provide one of the following or equal:

1) Premium FireLite by Nippon Electric Glass Company, Ltd. and distributed by Technical Glass Products, Kirkland, WA; 800/426-0279.

2) Contraflam by Saint-Gobain and distributed by Euroglass Glasrep Corp., White Plains, NY; 914/683-6704.

3) Inferno-Lite by Globe Amerada Glass Co., Elk Grove Village, IL; 800/323-8776.

B. Insulating Glass: ASTM E774, Class CBA; factory preassembled, sealed insulating glass units with 1/2-inch air space; aluminum spacer tube with desiccant held captive within, and dual seal construction.

1. Outer lite: 1/4-inch clear plate glass or tempered safety glass as shown or specified, with low-emissivity (low-E) coating equal to Viracon's Solarscreen 80 on the number-two (inside) surface.
2. Inner lite: 1/4-inch clear plate glass or tempered safety glass as shown or specified.

C. Safety Plastic: Clear, monolithic polycarbonate sheet complying with the following:

1. Abrasion resistance: Maximum 3.1 percent change in haze when tested in accordance with ASTM D1044 for both surfaces.
2. UV-resistance: Maximum 2.0 yellowing index after three years exposure per ASTM D1925.
3. Flammability: Meet BOCA combustibility classification C1: Horizontal burn rate of one inch per minute or less when tested at a nominal thickness of 0.060 inch, or in the thickness intended for use, in accordance with ASTM D635.

D. Glass Lens: Cast, clear glass, flat top with light sandblast texture, or acid etched if approved, to make it translucent, not transparent; vertical side (perimeter) roughened; top outer perimeter edge chamfered to 1/16 inch. Corning Glass Works, Pittsburgh Plate Glass Co., Blenko Glass Company distributed by Southern Plate Glass Company, or equal. Match texture, quality limiting defects, and translucency of existing units within the Metro system as directed by Engineer.

1. Defects shall be limited to a maximum of six air bubbles of 3/16 inch diameter or less with not more than three air bubbles occurring within the central three-inch diameter of lens.
2. Single-component clear silicone sealant: ASTM C920, Type S, Grade NS, Class 25, Use T; as manufactured by Dow, GE and Pecora, or approved equal.
3. Lead shims or lead rope: Section Shims die-cut from soft sheet lead; sized to suit field conditions, generally 6-1/2 inch outside diameter, five-inch inside diameter; 1/16-inch and 1/8-inch thicknesses as approved; ropes of lead wool may be substituted for shims as approved; fabricated to ensure that glass lenses can be set flush with granite.

E. Glazing Accessories:

1. Sealant: Multi-component polyurethane; ASTM C920, Type M, Grade NS, Class 25, Use G; colored as required to match framing system in which installed.
2. Glazing compound: Single-component polyurethane; ASTM C920, Type S, Grade NS, Class 25, Use G; colored as required to match framing system in which installed.
3. Glazing tape: Preformed butyl tape, ASTM C1281; 100 percent solids, nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod (pre-shimming) as recommended in writing by tape and glass manufacturers for

application indicated; packaged on rolls with a release paper backing; by 3M Company, Tremco Manufacturing Co., or equal.

4. Pressure-sensitive tape: Vinyl electrical tape, 3M Company or equal.
5. Lock-Strip Gaskets: ASTM C542 dense neoprene extrusions; profile shown or required.
6. Compression Seal Gaskets: ASTM C864 neoprene extrusions; profile and hardness as shown or as required to maintain watertight seal.
7. Setting blocks: ASTM C864 neoprene extrusions, 70-90 durometer Shore A hardness; approximately full channel width, four inches long and high enough to afford correct cover and 3/8-inch edge clearance for the glass.
8. Edge blocks (spacers): ASTM C864 neoprene extrusions, 40-50 durometer Shore A hardness; approximately full channel width, three inches long and providing 3/8-inch edge clearance for the glass.
9. Glazing clips and points: Type, material and quantities as required and recommended by the manufacturers of the glazing media.
10. Glazing (face) gasket: Neoprene, formulated of compound meeting or exceeding physical property requirements of ASTM C509, continuous, 50 durometer hardness, providing 3/16-inch face clearance inside and outside.
11. Lead-shim ring: Continuous ring of sheet lead, of thickness required to bring top of cast glass lens level with surrounding granite.
12. Dielectric screw shield: Nylon expansion anchor, round head, sized to ensure snug fit in predrilled hole and to accommodate size of screw used.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Verify dimensions before proceeding; obtain measurements at structure for work to be fitted to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.

B. Remove dirt, dust, oil, moisture and other foreign substances from surfaces to receive glass and glazing accessories.

C. Clean glass surfaces and wipe dry.

3.02 INSTALLATION:

A. Coordinate work of this section with work of other trades.

B. Use only tempered safety glass in doors, sidelights and transoms.

C. Use only fire-rated glass in doors and windows located in fire-rated wall construction, except where wire glass is shown.

D. Size glass by measuring actual frames or sash. Sizes shown are approximate and are intended for estimating purposes only. Cut glass to form 3/8-inch bite on all sides, except as otherwise required by manufacturer's product data as submitted and approved.

E. Install glass or plastic using glazing gaskets or other glazing accessories as shown.

F. Set glass on setting blocks at each quarter point of sill with equal bearing for entire width of each panel. Accurately cut glass to fit frames and provide smooth edges with no sharp or ragged surfaces. Provide edge blocks to prevent glass from contact with side frames.

G. Unless otherwise shown, set glass in metal interior frames and doors or by back-face glazing with glazing compound; tape to prevent rattling. Reset glazing beads, if necessary, without marring or injuring finish.

H. Tape Glazing:

1. Position tape on fixed stops so that, when compressed by glass, exposed edges of tape are flush with or protrude slightly above sightline of stops.
2. Install tape continuously, but not necessarily in one continuous length. Do not stretch tape to make it fit opening. Do not overlap butt ends. Cut tape with sharp shears. Place joints in tape at corners of opening with adjoining lengths butted together, not lapped.
3. Seal joints in tape with compatible sealant approved by tape manufacturer.
4. Where framing joints are vertical, cover these joints by applying tape to head and sill first and then to jambs. Where framing joints are horizontal, cover these joints by applying tape to jambs and then to head and sill.
5. Place spacer or centering shims, three inches in length, 3/16 inch in height and 3/32 inch in thickness, every 18 inches under tape. Hold spacers in position by gently placing them in contact with underedge of tape.
6. Position setting blocks for installation of glass. Use setting blocks 1/4 inch in height.
7. Do not remove release paper from tape until just before each glazing unit is installed.
8. Align glass carefully to opening and press glass firmly in place. Apply removable stops and repeat application of spacers of centering shims. Ensure that they are seated as deeply as possible in channel. Fill interior opening in conventional manner with glazing compound.
9. Apply cap bead of sealant over exterior exposed edge of tape.

I. Set glass in exterior metal windows and doors with neoprene setting blocks at quarter points and neoprene spacers two inches long placed 18 inches on center, and glaze with sealants.

J. Install glass and glazing accessories in accordance with manufacturer's recommendations. Neatly apply sealants, compounds and tapes in straight lines parallel with glazing rebates and as shown.

K. Perform direct glazing in dry weather, 40F or warmer.

L. Tape edges of laminated glass and insulating glass with pressure-sensitive tape if sealant or glazing tape is incompatible with interlayer or seals of insulating glass. Do not expose edges of laminated glass to solvents, cleaners or prolonged contact with water.

M. Set lead-shim rings on lips at bottom of openings and glass lenses. Set glass lenses to bring flat face level with the top of granite, centered in openings. Use spacers to maintain lenses in position while filling the annular space with backer rod and sealant as shown.

3.03 INSTALLATION OF ELEVATOR HOISTWAYS:

A. Install glazing at elevator hoistways as shown and in accordance with applicable requirements for glass and glazing.

B. Size screw holes for dielectric screw shields to permit installation so as to prevent metal-to-metal contact between screws and frame.

C. Apply sealant around entire frame, inside and outside of exterior hoistways only, and at other areas where metals are joined resulting in unfilled space. *2

SECTION 08970

STRUCTURAL GLASS CURTAIN WALLS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section includes:
   1. Outside glazed, 2-1/2 by 6 inch system.
   1. Glass, glazing and connections for the all glass suspended facade in accordance with the Contract Documents.

B. Related Work Specified Elsewhere:
   1. Cast in Place Structural Concrete: Section 03300
   2. Seals and Sealants
   3. Paints and Coatings: Section 09900

1.02 REFERENCES:

A. American Architectural Manufacturers Association:
   1. AAMA MCWM-1 - Metal Curtain Wall Manual.

1.03 QUALITY ASSURANCE:

A. Glazing Material and System Design: Glass, glazing, system design and accessories are the sole responsibility of manufacturer; Pilkington Architectural or equal.

B. Installation shall be manufacturer installed or by an installer acceptable to the manufacturer. Provide letter signed by an authorized representative of the Manufacturer company stating that the installer is acceptable and qualified to install system. Provide list of acceptable bidders available to AR on request.
   1. The System installer is responsible for supplying and erecting the complete structural glazing system, coordinating and maintaining tolerances between structure and glazing system with individual suppliers and manufacturers, and installation of glazing system. Installer to be acceptable must have installed with his own force a minimum of three other projects and be approved in writing by an authorized representative of the Manufacturer Company.

C. Where safety glass is indicated or required by authorities have jurisdiction, provide type of products which comply with ANSI Z97.1 and testing requirements of 16 CFR, Part 1201 for category II materials.

D. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

E. Installer: Company specializing in performing work of this section with minimum three years documented experience and approved by manufacturer.

F. Design structural support framing components under direct supervision of Professional Engineer experienced in design of this work and licensed at projects location.

1.04 SYSTEM DESCRIPTION:

A. Design Requirements:
   1. Design Wind Load 30 psf
   2. Seismic Zone 2
   3. Live load deflection of supporting structure if any L/360.

B. Glazing System:
   1. Fittings are designed to give flush appearance to outward surface of glazing system. No exterior fittings or plates will be permitted.
   2. The design of the Planar fittings is the sole responsibility of Manufacturer. All fittings is critical to the design of the glass wall.
   3. Spring plate members are designed to prevent high stress concentration at the hole positions and must cope with:
      a. Negative and positive wind loading.
      b. Seismic loads
      c. Thermal movement
      d. Construction tolerances

      e. Live load and dead load movements

4. Movement diaphragms of stainless steel and durable flexible discs must be incorporated in connections to accommodate oversize holes in spring plates members which allow for thermal movement and glass manufacturing tolerances.
5. The system shall provide for unitized pre-fixing of all items to glass prior to erection.

1.05 SUBMITTALS

A. Shop Drawings: Shop drawings shall clearly indicate materials and methods, indicate coordination with other trades, and bear signed approval of the glazing system manufacturer and the glazing system installer, as well as the stamp of a licensed Professional Engineer at projects location.
B. Product Data: Material description and installation instructions for tapes, compounds, gaskets and other materials.
C. Samples:
   1. Submit sample of glass and glazing materials required for the Project. Samples of glass shall be 12 inch x 12 inch, samples of sealant or gasket shall be 12 inch.
   2. Submit sample of spring plate complete with glass, bolt and accessories.
D. Quality Assurance Compliance: Submit letters form Manufacturer's authorized representative and from the project installer stating that they are in compliance with the requirements of the Contract Documents.
E. Calculations: Submit calculations proving structural glazing systems performance and compliance with specified loads with stamp of licensed Professional Engineer registered at projects location.
F. Test Reports: Submit test reports from an independent laboratory in the United States certifying that t he fully suspended structural glazing system proposed for this use has been tested. Proposed deviations without test reports will not be considered.
G. Manufacturer's Installation Instructions: Special installation requirements.

1.06 PRE-INSTALLATION MEETINGS

A. Convene minimum one week prior to commencing work of this section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Handle work in accordance with AAMA MCWM -1 Curtain Wall Manual.
B. Protect prefinished metal surfaces withy wrapping or strippable coating. Do not use adhesive papers or sprayed coating which bond when exposed to sunlight or weather. Puncture wrappings at ends for ventilation.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Do not install sealants when surface temperature is less than 40 degrees F.
B. Maintain specified minimum temperature during and after installation of sealants.

1.09 WARRANTY

A. Manufacturer Warranty: Provide twelve year warranty for the design integrity, weatherability and durability of the System. Partial multiple warranties of various project elements will not be accepted.
B. Installer Warranty: Warrant the installation for a period of 5 years for installation and repairs of failures. Provide written requirements for notification of installer and terms for maintaining warranty provisions. Do not contradict the requirements of the Contract Documents.
C. The warranties submitted under this section shall not deprive the owner of other rights or remedies that the owner may have under other provisions of the Contract Documents and the laws of governing jurisdictions and is in addition to and runs concurrently with other warranties made by the Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.01 MATERIALS GENERAL

A. Aluminum
   1. Extruded aluminum shall be 6063-T6 alloy and temper.

B. Glass
   1. Insulated glass shall be 1 inch thick.

C. Dissimilar Metals
   1. All dissimilar metals must be properly insulated to prevent galvanic action.

D. Fasteners
   1. All fasteners shall be aluminum, stainless steel, or zinc plated steel.

E. Anchors
   1. Perimeter and floor line anchors shall be aluminum or steel. All steel anchors shall be properly insulated from the aluminum.

F. Thermal Barrier
   1. The thermal barrier shall be extruded EPDM used as an applied thermal isolator.

2.01 MATERIALS:

A. Glass:
   1. All glass must be fully tempered and heat soaked. Refer to Section 08800.
   2. Glass must be certified to be tempered to a minimum compressive strength of 16,000 PSI. Glass tempered to lower strengths will not be accepted.
   3. All glass must be horizontally tempered eliminating tong marks.
   4. All tempered glass must be heat soak tested to convert nickel sulfide inclusions from the alpha phase to the beta phase so that the glass will fracture in the test. Heat soak must comply with the European Din standard.
   5. Written warranties against nickel sulfide inclusions in lieu of heat soaking will not be accepted.
   6. All edges will be ground flat with a frosted appearance unless otherwise noted.
   7. All edge work, holes and notches in the tempered glass panels will be completed before tempering and shall comply with the requirements as stated below:
      a. Dimensional tolerance on panel size will be l mm of the theoretical dimension required.
      b. Squareness of each panel will be within 1/8 inch.
      c. Bow allowance is 0.1 percent.
      d. The positional tolerances on all holes will be 1mm from a single datum point.
   8. Flatness of glass is a key element of this specification. Average roller wave distortion must be certified not to exceed an average of 0.0010 inch, with a maximum sag at the leading and trailing edge of 0.25mm. A site inspection if required for roller wave and bow tolerances should be from a minimum distance of 10 feet.
   9. All glass must be manufactured in a factory where the quality control procedures are created under the terms of ISO 900 and are independently monitored.
   10. Prestress glass around holes to a level which is compatible with the design and use of the fittings. Check by differential surface refractometer on stress level.

B. Fittings:
   1. Planar fittings shall be predominantly manufactured from stainless steel Grade 315, Standard fittings will be Planar.
   2. The subcontractor shall demonstrate to the manufacture's satisfaction that stresses induced in the glass by these fittings are compatible with the strength of the glass and the needs of the performance section of this specification.
   3. The finish of all fittings will be as machined.
   4. Spring plates shall be designed to the manufacturer's specification. The design shall be shown by the Subcontractor to be compatible with the performance specification in all respects.
      a. Spring plates shall provide a tolerance capability which will cope with the full range of movements shown below:
         1) Thermal movements occurring as a result of differential coefficients of thermal expansion within the range specified. The components used within the system shall withstand noiselessly all thermal movements without any buckling , distortion cracking, failure of joint seals or undue stress on the glass or fixing assemblies.
         2) Deflection of edge beams due to loading applied after erection of the cladding to magnitude specified.
         3) Maximum side sway of structure due to wind load of the magnitude specified or seismic movement to the degree specified.
         4) Deflection due to self weight of the Planar system.
         5) Inward and outward movements due to the design wind load specified.

5. Countersunk Planar bolts will be bright machine finished, socket head bolt diameter 1-1/8 inch with hexagonal shank, stainless steel type 303.
   a. No exterior plates, caps, disks or buttons will be permitted.
6. Bushings will be Nylatron Polyamide.
7. Gaskets will be fully vulcanized fiber, neoprene or pre-cured silicone.

2.02 FABRICATION

A. General
   1. All aluminum vertical and horizontal main frame extrusions shall have a minimum wall thickness of .125" (3 mm).
B. Frame
   1. Frame components shall be mechanically fastened by means of extruded aluminum shear blocks attached to vertical mullions.
   2. Curtain wall system is able to accommodate separate interior and exterior finishes and colors.
C. Glazing
   1. Outside glazed curtain wall system shall be dry glazed with an exterior aluminum pressure plate and snap cover with interior and exterior dense EPDM preset gasket.
D. Finish: As selected by Architect

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Section 01300 - Administrative Requirements: Coordination and project conditions.
B. Verify dimensions, tolerances, and method of attachment with other work.
C. Examine surfaces receiving the Work. Verify dimensions of in-place and subsequent construction. Follow the recommendations of the FGMA as to inspection procedures. Do not begin work until unsatisfactory conditions have been corrected. Installation of work shall constitute acceptance of the related construction.

3.02 PREPARATION

A. Pre-Installation Meeting: Meet at the project site with the representatives of the glass and glazing materials manufacturers, architectural exposed structural steel fabricator and erector, sealant manufacturer, the glazing installer, Manufacturer's representative and Owner's representative. Review the glazing procedure and schedule, including the method of all glazing materials and framing sealants with each other and with like materials used in glass fabrication shall be established.

3.03 INSTALLATION

A. Install in accordance with manufacturer's requirements and the shop drawings.
B. Employ only experienced glaziers who have had previous experience with the materials and systems being applied. Use tools and equipment recommended by the glass manufacturer.
C. Plate to plate joints of glass are sealed with silicone sealant. Joint dimensions shall be designed to be compatible with sealant properties and live load movement of the structure.
D. Bolt Torque: Torque bolts to torques specified on shop drawings using calibrated tool. Lock torqued bolts into position to prevent back off. Reset calibrations regularly to ensure accurate torquing.
E. Maintain a minimum temperature of 40 degrees F. during glazing unless the manufacturer of the glazing material specifically agrees to application of this material at lower temperature. If job progresses or other conditions require glazing work when temperature is below 40 degrees F. (or below the minimum temperature recommended by the manufacturer), consult the manufacturer and establish the minimum provisions required to ensure satisfactory work.
F. Clean glazing connectors receiving glazing materials of deleterious substances which might impair the work. Remove protective coatings which might fail in adhesion or interfere with bond of sealants. Comply with manufacturer's instructions for final wiping of surfaces immediately before application of primer and glazing sealants. Wipe metal surfaces with Xylol or Toluol.
G. Inspect each unit of glass immediately before installation. Glass which has significant impact damage at edges, scratches or abrasion of faces, or any other

evidence of damage shall not be installed.

H. Sealant as specified in Section 07900.
   1. Sealants: Prime surfaces to receive glazing sealants where required, in accordance with manufacturer's recommendations, using recommended primers.

I. Locate setting blocks, if required by the drawings, at the quarter points of sill, but no closer than 6 inches to corners of glass. Use blocks of proper sizes to support the glass in accordance with manufacturer's recommendations.

J. Provide spacers to separate glass from spring plates.

K. Set glass in a manner which produces greatest possible degree of uniformity in appearance. Face all glass, which has dissimilar faces, with matching faces in the same direction

L. Use masking tape or other suitable protection to limit coverage of glazing materials to the surfaces intended for sealants.

M. Tool exposed surfaces of glazing materials.

N. Clean excess sealant from glass and support members immediately after application, using solvents or cleaners recommended by manufacturers.

3.04 CURING, PROTECTION AND CLEANING

A. Cure sealants in accordance with the manufacturer's instructions to attain maximum durability and adhesion to glass.

B. Clean all surfaces after installation, leaving all in a clean and workmanlike manner.

C. Final cleaning and protection after installation is the responsibility of others.

3.05 MANUFACTURER'S SERVICES

A.. Glass product manufacturers to provide field surveillance of installation of their products.

B. Monitor and report installation procedures and unacceptable conditions.

3.06 CLEANING

A. Remove protective material from pre-finished metal surface.

B. Wash down surfaces with solution of mild detergent in warm water, applied with soft, clean wiping cloths. Take care to remove dirt from corners. Wipe surfaces clean.

C. Remove excess sealant by moderate use of mineral spirits or other solvent acceptable to sealant manufacturer.

3.07 PROTECTION OF INSTALLED CONSTRUCTION

A. Protect finished work from damage.

END OF SECTION

D. Apply sealant around entire frame, inside and outside, and at other areas where metals are joined resulting in unfilled space. *3

3.04 INSTALLATION/RE-INSTALLATION OF PLATFORM GRANITE EDGE GLASS LENSES:

A. Install lead shims or lead rope.

B. Install glass lenses.

C. Apply sealant.

3.05 FIELD QUALITY CONTROL:

A. Hose Tests:
1. Upon completion of glazing and sealing, perform hose test against exterior glazing and framing members in the presence of the Engineer.
2. Use 5/8-inch minimum diameter hose operated at 40-psi pressure for a minimum of 10 minutes. Repair leaks as soon as surfaces are dry; retest until approved.

B. Breakage: Prior to final acceptance, replace damaged glass.

C. Dielectric Testing:
1. After installation at elevator hoistways, test for electrical isolation between screws and hoistway metal, using ohmmeter.
2. Resistance requirement: 10,000 ohms.
3. Replace screws and shields that do not meet resistance requirements and retest as for initial installation. Repeat as necessary until all screws meet resistance requirement.

3.06 CLEAN-UP:

D. At completion of work, remove labels, except fire labels, clean glass and remove excess glazing compound and sealant from frames and surrounding finish work.

E. Remove from site rubbish and debris resulting from work of this section.

F. Leave areas surrounding work in broom-clean condition.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES

***1**. Add 1.1 B. including 1. modification to all contracts requiring glass and glazing work for elevator hoistways.

***2**. Use first version of 3.3 C. for all contracts requiring glass and glazing work for elevator hoistways.

***3**. Use second version of 3.3 C. for all contracts not requiring glass and glazing work for elevator hoistways.

END OF SECTION

SECTION 09205

FURRING AND LATHING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing furring, lathing and accessories.

B. Related Work Specified Elsewhere:
1. Access Doors and Frames: Section 08305.
2. Plaster systems: Section 09215.
3. Portland cement plaster: Section 09220.

1.02 PERFORMANCE REQUIREMENTS:

A. Structural Performance of Ceiling Support Systems: Limit deflection of ceiling to less than 1/360 of span.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data for each product specified.
2. Shop Drawings: Furring layouts; locations of access panels, mechanical openings, light fixtures and electrical openings; and construction details.
3. Samples:
   a. Four of each of the following products used in the work:
      1) Furring Channels: 12 inches long
      2) Metal lath: 12 inches square.
      3) Studs, runner and caps: 12 inches long.
      4) Tie wire: 12 inches long.
      5) Fasteners, hangers and accessories.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A36, A641, A653, B69, C645, C847, C1063, E488.
3. ML/SFA: Guide Specifications for Metal Lathing and Furring.

B. Mockups: At the start of installation, construct panels for each type of finish and application required to verify selections made under Sample submittals and to demonstrate aesthetic effects as well as qualities of materials and execution. The mockups shall be a part of the Work. The work must be approved by the Engineer before installation can continue.Delete below if no fire-rated plaster assemblies.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Deliver products in the original unopened packages, containers or bundles each bearing name of manufacturer, brand designation, referenced number, type and class as applicable.

B. Store materials inside, under cover, and dry, protected from weather, direct sunlight, surface contamination, aging, corrosion, and damage from construction traffic and other causes. Use platforms or other means to protect products and materials from contact with the soil. Do not store materials on finished floors.

C. Handle materials so as to preclude breakage of packages or containers and damage to materials.

PART 2 - PRODUCTS

2.01 METAL SUPPORTS FOR SUSPENDED AND FURRED CEILINGS:

A. General: Size metal ceiling supports to comply with ASTM C1063, unless otherwise indicated.

B. Cast-in-Place and Post-installed Anchors in Concrete: Anchors of type indicated below, fabricated from corrosion-resistant materials, with holes or loops for attaching hanger wires; and with capability to sustain, without failure, a load equal to 5 times that imposed by ceiling construction, as determined by testing according to ASTM E488 conducted by a qualified independent testing agency.
1. Expansion anchor.

C. Wire for Hangers: ASTM A641, Galvanized carbon-steel wire, eight-gauge minimum, medium-temper, Class 3 coating.

D. Wire for Ties: ASTM A641, Galvanized carbon-steel wire, 16-gauge minimum for securing metal furring, 18-gauge minimum for securing metal lathe, medium-temper, Class 1 coating.

E. Resilient Furring Channels: Galvanized steel, minimum 0.0209-inch-thick base (uncoated) metal, approved type, standard with the manufacturer, similar to RC-1, U.S. Gypsum Company.

F. Channels: Cold-rolled steel, minimum 0.0598-inch-thick base (uncoated) metal and 7/16-inch-wide flanges, and as follows:
1. Carrying Channels: 1-1/2 inches deep, 475 lb/1000 feet.
2. Furring Channels: 3/4 inch deep, 300 lb/1000 feet.
3. Finish: ASTM A653, G60 hot-dip galvanized coating for framing.

G. Steel Studs for Furring Channels: ASTM C645, with flange edges of studs bent back 90 degrees and doubled over to form 3/16-inch-wide minimum lip (return), and complying with the following requirements for minimum thickness of base (uncoated) metal and for depth:
1. Thickness: 0.0478 inch, unless otherwise indicated.
2. Depth: As indicated.
3. Protective Coating: ASTM A653, G40 galvanized coating.

2.02 STEEL STUDS AND RUNNERS:

A. General: Provide steel studs and runners complying with the following requirements:
1. Protective Coating: ASTM A653, G40 hot-dip galvanized coating.Retain above or below. Verify availability and weight of galvanized coatings with manufacturers.Retain below if galvanized coating is only required at exterior and building perimeter locations.

B. Non-Load-Bearing Studs and Runners: ASTM C645 and complying with the following requirements for minimum thickness of base (uncoated) metal and other characteristics:

1. Thickness: 0.0478 inch.
2. Depth: As indicated.

2.03 VERTICAL METAL FURRING:

A. General: Provide vertical furring complying with the following requirements:
1. Protective Coating: ASTM A653, G40 hot-dip galvanized coating.

B. Channel Furring and Braces: Cold-rolled steel, minimum 0.0598-inch-thick base (uncoated) metal and 3/4-inch-deep-by-7/16-inch-wide flanges, 300 lb/1000 feet.

C. Hat Channels: Hat-shaped screwable furring channels, 7/8 inch deep, formed from zinc-coated (galvanized) steel sheet, minimum 0.0179-inch-thick, Grade 33.

D. Furring Brackets: Serrated-arm type, minimum 0.0329-inch-thick base (uncoated) metal, adjustable from 1/4- to 2-1/4-inch wall clearance for channel furring.

2.04 LATH:

A. Expanded-Metal Lath: Comply with ASTM C847 for material, type, configuration, and other characteristics indicated below.
1. Material: Fabricate expanded-metal lath from sheet metal conforming to the following:
a. Galvanized Steel: Structural-quality, zinc-coated (galvanized) steel sheet complying with ASTM A653, G60 minimum coating designation, unless otherwise indicated.
2. Diamond-Mesh Lath: Comply with the following requirements:
a. For applications directly to masonry or concrete:
1) Configuration: Self-furring.
2) Weight: 2.5-lb/sq. Yd.
b. For reinforcing at corners of opening or at internal corners:
1) Configuration: Flat.
2) Weight: 2.5-lb/sq. Yd.
c. For all other applications:
1) Configuration: Flat.
2) Weight: 3.4-lb/sq. Yd.

2.05 ACCESSORIES:

A. General: Comply with material provisions of ASTM C1063 and the requirements indicated below; coordinate depth of accessories with thicknesses and number of plaster coats required.
1. Galvanized Steel Components: Fabricated from zinc-coated (galvanized) steel sheet complying with ASTM A653, G40 minimum coating designation.
2. Zinc-Alloy Components: ASTM B69, 99 percent pure zinc.

B. Metal Corner Reinforcement: Expanded, large-mesh, diamond-metal lath fabricated from zinc-alloy or welded-wire mesh fabricated from 0.0475-inch-diameter, zinc-coated (galvanized) wire and specially formed to reinforce external corners of portland cement plaster on exterior exposures while allowing full plaster encasement.

C. Cornerbeads: Small nose cornerbeads fabricated from the following metal, with expanded flanges of large-mesh diamond-metal lath allowing full plaster encasement.
1. Zinc Alloy: Minimum 0.0207-inch-thick.
2. Galvanized Steel: Minimum 0.0179-inch-thick.

D. Casing Beads: Square-edged style, with expanded flanges of the following material:Retain 1 of first 4 below or retain last with 2 or more of first 4.
   1. Zinc Alloy: Minimum 0.0207-inch-thick.
   2. Galvanized Steel: Minimum 0.0179-inch-thick.

E. Curved Casing Beads: Square-edged style, fabricated from aluminum coated with clear plastic, preformed into curve of radius indicated.

F. Control Joints: Prefabricated, of material and type indicated below:
   1. Zinc Alloy: Minimum 0.0207-inch-thick.
   2. Galvanized Steel: Minimum 0.0179-inch-thick.
   3. One-Piece Type: Folded pair of nonperforated screeds in M-shaped configuration, with expanded or perforated flanges.
   4. Two-Piece Type: Pair of casing beads with back flanges formed to provide slip-joint action, adjustable for joint widths from 1/8 to 5/8 inch.
      a. Provide removable protective tape on plaster face of control joints.

G. Lath Attachment Devices: Material and type required by ASTM C1063 for installations indicated.

H. Fasteners: Clips and nails, standard with furring and lathing manufacturer.

I. Anchors: Stainless steel, Alloy 303 or 304, with the following additional requirements:
   1. Type: Through bolt in steel; expansion bolt in concrete; toggle bolt in CMU.
   2. Pull-out strength: 1,200 pounds minimum
   3. Shear strength: 1,500 pounds minimum.

PART 3 - EXECUTION

3.01 INSTALLATION OF LATH AND FURRING, GENERAL:

A. Standards: Comply with ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," and with the requirements of ASTM C841 and ASTM C1063.

B. Install supplementary framing, blocking, and bracing at terminations in work and for support of fixtures, equipment services, heavy trim, grab bars, handrails, furnishings, and similar work to comply with details indicated or, if not otherwise indicated, to comply with applicable written instructions of lath and furring manufacturer.

C. Isolation: Where lathing and metal support system abuts building structure horizontally and where partition or wall abuts overhead structure, sufficiently isolate from structural movement to prevent transfer of loading from building structure. Install slip- or cushion-type joints to absorb deflections but maintain lateral support.
   1. Frame both sides of control joints independently and do not bridge joints with furring and lathing or accessories.

D. Install additional framing, furring, runners, lath, and beads, as required to form openings and frames for other work as indicated. Coordinate support system for proper support of framed work that is not indicated to be supported independently of metal furring and lathing system.

3.02 INSTALLATION OF CEILING SYSTEMS:

A. Preparation and Coordination:

1. Do not install furring until pipe, conduits and other equipment are in place and inspected.
2. Coordinate installation of ceiling suspension system with installation of overhead structural systems to ensure inserts and other structural anchorage provisions have been installed to receive ceiling hangers in a manner that will develop their full strength and at spacings required to support ceiling.
   a. Furnish concrete inserts, and other anchorage devices indicated, to other trades for installations well in advance of time needed for coordination with other work.
   b. Perform cutting of construction necessary to install furring and lathing around ducts, conduits, pipes and equipment.

B. Hanger Installation: Attach hangers to structure above ceiling to comply with ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," and with referenced standards.
1. Do not attach hangers to metal deck tabs.

C. Install ceiling suspension system components of sizes and spacings indicated, but not in smaller sizes or greater spacings than those required by referenced lathing and furring installation standards.
1. Wire Hangers: Suspend hangers from overhead construction. Coordinate work with construction work from which it is suspended. Space wire hangers not over 42 inches o.c., parallel with and not over 36 inches perpendicular to direction of carrying channels, unless otherwise indicated, and within 6 inches of carrying channel ends. Wrap wire hanger around carrying channel so as to develop full strength of hangers.
2. Carrying Channels: Space carrying channels not over 42 inches o.c. with 36-inch o.c. hanger spacing. Use shims or other methods, if necessary, to level channels before securing in place.
3. Furring Channels to Receive Metal Lath: Space furring channels not over 12 inches o.c. Secure furring channels to carrying channels, saddle-tied with tie wire or fastened with approved clips.

D. Where masonry partitions are erected to ceiling height only, continue suspended ceilings across partition tops without bearing on partitions. Place carrying channels, which are adjacent to and parallel to partitions, not more than six inches from face of partition.

E. Where furred ceilings are shown or specified, attach furring channels directly to the overhead construction.

F. Where shown or specified provide resilient furring channels in lieu of conventional furring channels.

G. Provide additional rods, clips and other accessories as necessary to achieve complete furring and lathing job.

3.03 INSTALLATION OF STEEL STUD WALL AND PARTITION SUPPORT SYSTEMS:

A. General: Install components of systems to comply with written instructions of steel stud manufacturer for applications indicated and as follows:
1. For non-load-bearing stud systems, comply with ASTM C754.

B. Steel Stud Systems to Receive Metal Lath: Comply with requirements of ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," applicable to each installation condition and type of metal stud system indicated.
1. Extend and attach partition support systems to structure above suspended ceilings, unless otherwise indicated.

3.04 INSTALLATION OF VERTICAL METAL FURRING:

A. Install vertical metal furring components of sizes and spacings indicated, but not in smaller sizes or greater spacings than those required by referenced ML/SFA standard.

B. For furring on interior side of exterior walls, provide furring brackets, unless otherwise indicated

C. Metal Furring to Receive Metal Lath: Comply with requirements of ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," applicable to each installation condition indicated.

3.05 INSTALLATION OF LATHING:

A. Install metal lath for the following applications where plaster base coats are required. Provide appropriate type, configuration, and weight of metal lath selected from materials indicated that comply with referenced ML/SFA specifications and ASTM lathing installation standards.
   1. For applications directly to masonry or concrete use 2.5-lb/sq. Yd. minimum weight, self-furring, diamond-mesh lath.
   2. For reinforcing at corners of opening or at internal corners 2..5-lb/sq. Yd. minimum weight, diamond-mesh lath.
   3. For all other applications use 3.4-lb/sq. Yd. minimum weight, diamond-mesh lath.

B. Lathing on Ceilings:
   1. Apply metal lath with long dimension of sheet at right angle to furring channels.
   2. Securely tie metal lath to supporting framing with tie wire.
   3. Tie each sheet of lath at least four times in width to each support. Lap ends and sides of sheet not less than ½-inch and lace together at approximately six inches on center. Stagger ends of sheets.

C. Lathing on Stud Partitions and Furred Walls:
   1. Provide metal lath where shown.
   2. Attach metal lath to furring channels and studs with tie wire.Insert other applications if required.

3.06 CLEANING:

A. Remove from site rubbish and debris caused by this work..

B. Leave rooms and areas in broom-clean condition.

END OF SECTION

SECTION 09255

DRYWALL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing non-loadbearing drywall systems, including metal studs, metal furring and acoustical insulation.

B. Related Work Specified Elsewhere:
   1. Seals and Sealants: Section 07900.
   2. Building Insulation: Section 07210.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements for approval and with the additional requirements as specified for each.
   1. Product Data: For each type of the product indicated.
   2. Samples:
      a. Trim Accessories: Full-size sample in 12-inch long length for each trim accessory indicated.
      b. Textured Finishes: Manufacturer's standard size for each textured finish indicated and on same backing indicated for Work.
   3. Certification.
      a. Certificates from the gypsum-wallboard manufacturer verifying that materials furnished meet specified requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM: C36, C423, C475, C641, C645, C665, C754, C834, C840, C931, C954, C919, C1002, C1177, C1047, D226, E84, E90, E119, E413, E497.
   3. ASTM A 118.9, C 919.

B. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.

C. Sound Transmission Characteristics: For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.

B. Store materials inside under cover and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes. Stack gypsum panels flat to prevent sagging.

1.05 JOB CONDITIONS:

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.

PART 2 - PRODUCTS

2.01 STEEL PARTITION AND SOFFIT FRAMING:

A. Components, General: As follows:
   1. Comply with ASTM C 754 for conditions indicated.
   2. Steel Sheet Components: Complying with ASTM C 645 requirements for metal and with manufacturer's standard corrosion-resistant zinc coating.

B. Steel Studs and Runners: ASTM C 645, non-loadbearing
   1. Minimum Base Metal Thickness: 20 ga.
   2. Depth: As shown.

C. Deep-Leg Deflection Track: ASTM C 645 top runner with 2-inch- deep flanges.

D. Proprietary Deflection Track: Steel sheet top runner manufactured to prevent cracking of gypsum board applied to interior partitions resulting from deflection of structure above; in thickness indicated for studs and in width to accommodate depth of studs.

E. Proprietary Firestop Track: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

G. Cold-Rolled Channel Bridging: 0.0538-inch bare steel thickness, with minimum 1/2-inch- wide flange.
   1. Depth: As shown.
   2. Clip Angle: 1-1/2 by 1-1/2 inch, 0.068-inch-thick, galvanized steel.

H. Hat-Shaped, Rigid Furring Channels: ASTM C 645.

I. Resilient Furring Channels: 1/2-inch deep, steel sheet members designed to reduce sound transmission.

J. Cold-Rolled Furring Channels: 0.0538-inch bare steel thickness, with minimum 1/2-inch-wide flange.
   1. Depth: As indicated.
   2. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum bare steel thickness of 0.0312 inch.
   3. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.0625-inch diameter wire, or double strand of 0.0475-inch diameter wire.

K. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, minimum bare metal thickness of 0.0179 inch, and depth required to fit insulation thickness indicated.

L. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

2.02 INTERIOR GYPSUM WALLBOARD

A. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.

B. Gypsum Wallboard: ASTM C 36.
   1. Regular Type:Regular-type gypsum panels are also available in 1/4- and 3/8-inch (6.4- and 9.5-mm) thicknesses for limited applications.
      a. Thickness: 1/2 inch, unless otherwise indicated.
      b. Long Edges: Tapered and featured (rounded or beveled) for prefilling.
      c. Location: As indicated.
   2. Type X:
      a. Thickness: 5/8 inch.
      b. Long Edges: Tapered and featured (rounded or beveled) for prefilling.
      c. Location: Where required for fire-resistance-rated assembly or as indicated

C. Flexible Gypsum Wallboard: ASTM C 36, manufactured to bend to fit tight radii and to be more flexible than standard regular-type panels of the same thickness.
   1. Thickness: 1/4 inch.
   2. Long Edges: Tapered.
   3. Location: As indicated

D. Sag-Resistant Gypsum Wallboard: ASTM C 36, manufactured to have more sag resistance than regular-type gypsum board.
   1. Thickness: 1/2 inch.
   2. Long Edges: Tapered.
   3. Location: Ceiling surfaces

E. Proprietary, Special Fire-Resistive Type: ASTM C 36, having improved fire resistance over standard Type X.

F. Foil-Backed Gypsum Wallboard: ASTM C 36.

G. Proprietary Abuse-Resistant Gypsum Wallboard: ASTM C 36, manufactured to produce greater resistance to surface indentation and through-penetration than standard gypsum panels.

2.03 EXTERIOR GYPSUM PANELS FOR CEILINGS AND SOFFITS

A. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.

B. Exterior Gypsum Soffit Board: ASTM C 931/C 931M, with manufacturer's standard edges.
   1. Core: ½ inch, regular type or 5/8 inch Type X.

C. Glass-Mat Gypsum Sheathing Board: ASTM C 1177/C 1177M.

2.04 TILE BACKING PANELS

A. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.

B. Cementitious Backer Units: ASTM A 118.9

2.05 TRIM ACCESSORIES:

A. Interior Trim: ASTM C 1047
   1. Material: , manufacturer's standard metal trim, formed from galvanized or aluminum-coated steel, or rolled zinc.
   2. Shapes:
      a. Cornerbead: Use at outside corners.
      b. Bullnose Bead: Use where indicated.
      c. LC-Bead (J Bead): Use at exposed panel edges.
      d. L-Bead: Use where indicated.
      e. U-Bead: Use where indicated.
      f. Expansion Joint Use where indicated.
      g. Curved-Edge Cornerbead: With notched or flexible flanges; use at curved openings.

B. Exterior Trim: ASTM C 1047.
   1. Material: Hot-dip galvanized steel sheet or rolled zinc.
   2. Shapes:
      a. Cornerbead: Use at outside corners.
      b. LC-Bead (J-Bead): Use at exposed panel edges.
      c. Expansion (Control) Joint.

2.06 JOINT TREATMENT MATERIALS:

A. General: Comply with ASTM C 475.

B. Joint Tape:
   1. Interior Gypsum Wallboard: Paper.
   2. Exterior Gypsum Soffit Board: Paper.
   3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

D. Joint Compound for Exterior Applications:

1. Exterior Gypsum Soffit Board: Use setting-type taping and setting-type, sandable topping compounds.
2. Glass-Mat Gypsum Sheathing Board: As recommended by manufacturer.

E. Joint Compound for Tile Backing Panel:
1. Cementitious Backer Units: As recommended by manufacturer

2.07 ACOUSTICAL SEALANT:

A. Acoustical Sealant for Exposed and Concealed Joints: Nonsag, paintable, nonstaining, latex sealant complying with ASTM C 834 that effectively reduces airborne sound transmission through perimeter joints and openings in building construction.

2.08 AUXILIARY MATERIALS

A. General : Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

C. Steel Drill Screws: ASTM C 1002, unless otherwise indicated
1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Isolation Strip at Exterior Walls:
1. Asphalt-Saturated Organic Felt: ASTM D 226, Type I (No. 15 asphalt felt), nonperforated.
2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

E. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

F. Thermal Insulation: As specified in Section 07210.

G. Vapor Barrier: As specified in Section 07210.

2.09 TEXTURE FINISHES

A. Primer: As recommended by textured finish manufacturer.

B. Polystyrene Aggregate Ceiling Finish: Water-based, job-mixed, polystyrene aggregate finish with flame-spread and smoke-developed indices of not more than 25 when tested according to ASTM E 84.

C. Aggregate Finish: Water-based, job-mixed, aggregated, drying-type texture finish for spray application.

D. Acoustical Finish: Water-based, chemical-setting or drying-type, job-mixed texture finish for spray application:
   1. Application Thickness: 1/2 inch.
   2. Fire-Test-Response Characteristics: Indices when tested according to ASTM E 84 as follows:
      a. Flame Spread: Less than 25.
      b. Smoke Developed: Less than 450.
   3. NRC: 0.55 according to ASTM C 423.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLING STEEL PARTITION AND SOFFIT FRAMING:

A. Install tracks (runners) at floors, ceilings, and structural walls and columns where gypsum board assemblies abut other construction.
   1. Where studs are installed directly against exterior walls, install asphalt-felt or foam-gasket isolation strip between studs and wall.

B. Installation Tolerance: Install each steel framing and furring member so fastening surfaces vary not more than 1/8 inch3 mm from the plane formed by the faces of adjacent framing.

C. Extend partition framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing over frames for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.
   1. Cut studs 1/2 inch13 mm short of full height to provide perimeter relief.
   2. For fire-resistance-rated and STC-rated partitions that extend to the underside of floor/roof slabs and decks or other continuous solid-structure surfaces to obtain ratings, install framing around structural and other members extending below floor/roof slabs and decks, as needed to support gypsum board closures and to make partitions continuous from floor to underside of solid structure.
      a. Terminate partition framing at suspended ceilings where indicated

D. Install steel studs so flanges point in the same direction and leading edge or end of each panel can be attached to open (unsupported) edges of stud flanges first.

E. Frame door openings to comply with GA-600 and with gypsum board manufacturer's applicable written recommendations, unless otherwise indicated. Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.
   1. Install two studs at each jamb, unless otherwise indicated.

2. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint.
3. Extend jamb studs through suspended ceilings and attach to underside of floor or roof structure above.
4. Frame openings other than door openings the same as required for door openings, unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.

F. Z-Furring Members:
1. Erect insulation vertically and hold in place with Z-furring members spaced 24 inches o.c.
2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.
3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches from corner and cut insulation to fit.
4. Until gypsum board is installed, hold insulation in place with 10-inch staples fabricated from 0.0625-inch- diameter, tie wire and inserted through slot in web of member.

G. Vapor Barrier: Install to comply with requirements specified in Section 07210.

3.03 APPLYING AND FINISHING PANELS, GENERAL:

A. Gypsum Board Application and Finishing Standards: ASTM C 840 and GA-216.

B. Install sound attenuation blankets before installing gypsum panels, unless blankets are readily installed after panels have been installed on one side.

C. Install ceiling board panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in the central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

D. Install gypsum panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.

E. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

F. Attach gypsum panels to steel studs so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

G. Attach gypsum panels to framing provided at openings and cutouts.

H. Do not attach gypsum panels across the flat grain of wide-dimension lumber, including floor joists and headers. Float gypsum panels over these members using resilient channels, or provide control joints to counteract wood shrinkage.

I. Form control and expansion joints with space between edges of adjoining gypsum panels.

J. Cover both faces of steel stud partition framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.

K. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft.0.7 sq. m in area.

L. Fit gypsum panels around ducts, pipes, and conduits.

M. Where partitions intersect open concrete coffers, concrete joists, and other structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by coffers, joists, and other structural members; allow 1/4- to 3/8-inch- wide joints to install sealant.

N. Isolate perimeter of non-load-bearing gypsum board partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch- wide spaces at these locations, and trim edges with U-bead edge trim where edges of gypsum panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

O. Floating Construction: Where feasible, including where recommended in writing by manufacturer, install gypsum panels over wood framing, with floating internal corner construction.

P. STC-Rated Assemblies: Seal construction at perimeters, behind control and expansion joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and manufacturer's written recommendations for locating edge trim and closing off sound-flanking paths around or through gypsum board assemblies, including sealing partitions above acoustical ceilings.

Q. Space fasteners in gypsum panels according to referenced gypsum board application and finishing standard and manufacturer's written recommendations.
   1. Space screws a maximum of 12 inches o.c. for vertical applications.

R. Space fasteners in panels that are tile substrates a maximum of 8 incheso.c.

3.04 PANEL APPLICATION METHODS:

A. Single-Layer Application:
   1. On ceilings, apply gypsum panels before wall/partition board application to the greatest extent possible and at right angles to framing, unless otherwise indicated.
   2. On partitions/walls, apply gypsum panels vertically (parallel to framin),, unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
      a. Stagger abutting end joints not less than one framing member in alternate courses of board.
      b. At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.
   3. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.

B. Multilayer Application on Ceilings: Apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints 1 framing member, 16 inches minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.

C. Multilayer Application on Partitions/Walls: Apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.

1. Z-Furring Members: Apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.

D. Single-Layer Fastening Methods: Apply gypsum panels to supports with steel drill screws.

E. Multilayer Fastening Methods: Fasten base layers and face layers separately to supports with screws.

F. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.

G. Curved Partitions:

1. Install panels horizontally and unbroken, to the extent possible, across curved surface plus 12-inch300-mm-long straight sections at ends of curves and tangent to them.
2. On convex sides of partitions, begin installation at one end of curved surface and fasten gypsum panels to studs as they are wrapped around curve. On concave side, start fastening panels to stud at center of curve and work outward to panel ends. Fasten panels to framing with screws spaced 12 inches o.c.
3. For double-layer construction, fasten base layer to studs with screws 16 inches o.c. Center gypsum board face layer over joints in base layer, and fasten to studs with screws spaced 12 inches o.c.

H. Exterior Soffits and Ceilings: Apply exterior gypsum soffit board panels perpendicular to supports, with end joints staggered and located over supports.

1. Install with 1/4-inch open space where panels abut other construction or structural penetrations.
2. Fasten with corrosion-resistant screws.

I. Tile Backing Panels:

1. Cementitious Backer Units: ANSI A108.11, at locations indicated to receive tile.
2. Areas Not Subject to Wetting: Install standard gypsum wallboard panels to produce a flat surface except at showers, tubs, and other locations indicated to receive water-resistant panels.
3. Where tile backing panels abut other types of panels in the same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.05 INSTALLING TRIM ACCESSORIES:

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Control Joints: Install control joints at locations shown or indicated. Install control joints according to ASTM C 840 and in specific locations approved by the Engineer for visual effect.

3.06 FINISHING GYPSUM BOARD ASSEMBLIES:

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints**,** beveled edges, and damaged surface areas.

C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C 840, for locations indicated:
   1. Level 2: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges where.
   2. Level 3: Embed tape and apply separate first and fill coats of joint compound to tape, fasteners, and trim flanges at surfaces recivfing textured finish.

E. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.

F. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.07 APPLYING TEXTURE FINISHES:

A. Surface Preparation and Primer: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Apply primer to surfaces that are clean, dry, and smooth.

B. Texture Finish Application: Mix and apply finish using powered spray equipment, to produce a uniform texture matching approved mockup and free of starved spots or other evidence of thin application or of application patterns.

C. Prevent texture finishes from coming into contact with surfaces not indicated to receive texture finish by covering them with masking agents, polyethylene film, or other means. If, despite these precautions, texture finishes contact these surfaces, immediately remove droppings and overspray to prevent damage according to texture finish manufacturer's written recommendations.

3.08 FIELD QUALITY CONTROL:

A. Above-Ceiling Observation: Before Contractor installs gypsum board ceilings, Architect will conduct an above-ceiling observation and report deficiencies in the Work observed. Do not

proceed with installation of gypsum board to ceiling support framing until deficiencies have been corrected.

1. Notify the Engineer in advance of date and time when Project, or part of Project, will be ready for above-ceiling observation.
2. Before notifying the Engineer, complete the following in areas to receive gypsum board ceilings:
    a. Installation of 80 percent of lighting fixtures, powered for operation.
    b. Installation, insulation, and leak and pressure testing of water piping systems.
    c. Installation of air-duct systems.
    d. Installation of air devices.
    e. Installation of mechanical system control-air tubing.
    f. Installation of ceiling support framing.

END OF SECTION

SECTION 09 30 19

PAVER TILING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Paver tile.
2. Truncated dome tile.
3. Waterproof membrane for thinset applications.
4. Crack isolation membrane.
5. Metal edge strips.

B. Related Requirements:

1. Section 03 30 00 "Cast-in-Place Concrete"; Concrete overlay.
2. Section 07 92 00 "Joint Sealants."
3. Section 07 95 00 "Expansion Control."
4. Section 07 95 13 "Expansion Joint Cover Assemblies."
5. Section 09 30 13 "Ceramic Tiling."

1.03 DEFINITIONS

A. General: Definitions in the ANSI A108 series of tile installation standards apply to Work of this Section unless otherwise specified.

B. American National Standards Institute (ANSI) - "Specifications for Installation of Ceramic Tile.", ANSI A108 Series:

1. ANSI A108.01, ANSI A108.02, ANSI A108.1A, ANSI A108.1B, ANSI A108.1C, ANSI A108.4, ANSI A108.5, ANSI A108.6, ANSI A108.8, ANSI A108.9, ANSI A108.10, ANSI A108.11, ANSI A108.12, ANSI A108.13, ANSI A108.14, ANSI A108.15, ANSI A108.16, ANSI A108.17.

C. Quarry Tile: Quarry tiles are unglazed or glazed units with a facial area usually exceeding 9 sq. in. and that are usually 3/8, 1/2, or 3/4 inch thick.

D. Module Size: Actual tile size plus joint width.

1.04 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.05 SEQUENCING AND SCHEDULING

A. Sequence paver tile installation with other work to minimize possibility of damage and soiling during remainder of construction period.

B. Install paver tile and accessories only after other finishing operations, including painting, are completed.

1.06 SUBMITTALS

A. Product Data: For each type of product; include details, materials manufacturers' catalogs, recommendations and applicable specifications.

B. Sustainable Design Submittals:

1. LEED Submittals:
   a. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
   b. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regionally manufactured and regionally extracted and manufactured materials. Include statement indicating cost for each regionally manufactured material.
      1) Include statement indicating location of manufacturer and distance to Project for each regionally manufactured material.
      2) Include statement indicating location of manufacturer and point of extraction, harvest, or recovery for each raw material used in regionally extracted and manufactured materials. Indicate distance to Project and fraction by weight of each regionally manufactured material that is regionally extracted.
   c. Product Data for Credit IEQ 4.1: For adhesives, documentation including printed statement of VOC content.
   d. Product Data for Credit IEQ 4.3: For paver tile sealers, documentation indicating that products comply with requirements of FloorScore certification.

C. Shop Drawings:

1. Show locations, layout of paver tile, and sizes of each type of paver tile and tile pattern. Include widths, details of installation, and locations and sizes of expansion, contraction, control, and isolation joints in substrates and finished paver quarry tile surfaces. Show paver thresholds.

2. Indicate limits of ramps (surfaces with a slope greater than 1:20) and areas where tile with abrasive aggregate is required according to its coefficient of friction.

D. Samples for Initial Selection: For tile, grout, and accessories involving color selection.

1. Three 24-inch square panels showing paver tile, bonding method, joint materials, expansion-joint sealants, color and texture.

2. Demonstration sample of platform edge paver installation where directed , minimum six feet wide by 16 feet long along platform edge granite. Approved sample may be used in work.

E. Samples for Verification:

1. Full-size units of each type of paver quarry tile in each finish required.

2. Assembled Samples with grouted joints for each type of paver quarry tile and for each finish required, at least 36 inches square and mounted on a rigid panel. Use grout of type and in color(s) approved for completed Work.
3. Range Samples consisting of at least three full-size units of each type of paver quarry tile, exhibiting extremes of the full range of color and other visual characteristics expected. Range Samples establish the standard by which individual paver quarry tiles and thresholds are judged.
4. Paver thresholds in 6-inch lengths.
5. Metal edge strips in 6-inch lengths.

F. Certification:
1. Master Grade Certificate: ANSI A137.1.
2. Mortar and grout manufacturer's certification that materials furnished are suitable for intended use and meet specified requirements.
3. Certified test reports by approved independent testing facility for specified properties and tests.

G. Qualification Data: For Installer.

H. Product Test Reports: For tile-setting and -grouting products and paver quarry tile.

1.07 CLOSEOUT SUBMITTALS

A. Maintenance Data: For dimension paver quarry tile to include in maintenance manuals.

1.08 EXTRA STOCK AND MAINTENANCE MATERIALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Dimension Paver Tile: Furnish quantity of full-size units equal to 3 percent of amount installed, for each type, composition, color, pattern, and size indicated.
2. Paver Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.09 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Materials and installation shall be in compliance with the applicable building code and other laws and regulations of the authorities having jurisdiction (AHJ).

B. Reference Standards and Specifications: Provide paver tiling in compliance with the following industry standards and as specified.
1. American Association of State Highway and Transportation Officials (AASHTO):
a. AASHTO M153. Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
2. Americans with Disabilities Act (ADA).
3. American National Standards Institute (ANSI):
a. A108-AN-2, A108.1C, A108.4, A108.5, A108.6, A108.10, A118.3, A118.4, A118.6, A136.1, A137.1.

4. ASTM International (ASTM):
    a. ASTM A1064, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete."
    b. ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.
    c. ASTM C501, Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser.
    d. ASTM C373, Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products, Ceramic Tiles, and Glass Tiles
    e. ASTM C485, Standard Test Method for Measuring Warpage of Ceramic Tile.
    f. ASTM C499, Standard Test Method for Facial Dimensions and Thickness of Flat, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete Rectangular Ceramic Wall and Floor Tile.
    g. ASTM C836, Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course.
    h. ASTM C920, Standard Specification for Elastomeric Joint Sealants.
5. Tile Council of North America (TCNA):
    a. TCNA Handbook for Ceramic Tile Installation.

C. Installer Qualifications:

1. Installer is [a five-star member of the National Tile Contractors Association] [or] [a Trowel of Excellence member of the Tile Contractors' Association of America].
2. Installer's supervisor for Project holds the International Masonry Institute's Foreman Certification.
3. Installer employs [Ceramic Tile Education Foundation Certified Installers] [or] [installers recognized by the U.S. Department of Labor as Journeyman Tile Layers].

D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockup of each type of paver floor tile installation.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. Dry-Laid Mockups: Lay out tiles in dry-laid mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Lay out mockup of each type of paver floor tile installation.
2. paver Maintain dry-laid mockups in an undisturbed condition until equivalent areas of the completed Work are approved to serve as mockups.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to site in original unopened moisture proof containers clearly labeled indicating manufacturer's name, type, grade and color.

B. Provide mortar and grout materials with labels certifying compliance with specifications and that they are of the types recommended by manufacturer for this application.

C. Store materials on pallets so as to prevent damage and moisture penetration.

D. Handle materials so as to prevent breakage of containers and damage to materials.

E. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use.

F. Store paver tile and cementitious materials on elevated platforms, under cover, and in a dry location.

G. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

H. Store liquid materials in unopened containers and protected from freezing.

1.11 FIELD CONDITIONS

A. Environmental Conditions:

1. Do not start paver-tile work unless the ambient temperature of the area in which the work occurs is at least 50F and rising and is maintained at not less than 50F without interruption while the work is being done and for at least 72 hours after completion of the work.

B. Substrate Conditions:

1. Do not start paver-tile work unless surfaces to receive tile are in satisfactory condition.

2. Commencement of paver-tile work constitutes Contractor's acceptance of the subfloor condition in accordance with ANSI A108-AN-2, General Requirement for Subsurfaces.

C. Environmental Limitations: Do not install paver quarry tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design: Summitville Red Flashed matching WMATA standard quarry tile pavers.

B. Source Limitations:

1. Tile and Thresholds: Obtain each paver tile product type from single source from single producer.
   a. For each tile product type, provide one tile variety
   b. Where two or more tile product types are identical, except for size or finish, provide same variety for each type.
   c. Where threshold types are identical to tile types, except for size or finish, provide same variety
   d. Obtain each variety of tile from same location in a single quarry with resources to provide materials of consistent quality in appearance and physical properties.

2. Setting and Grouting Materials:
   a. Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from single manufacturer and each aggregate from single source or producer.
   b. Obtain setting and grouting materials, except for unmodified Portland cement and aggregate, from single manufacturer.
   c. Obtain waterproof membrane and crack isolation membrane, except for sheet products, from manufacturer of setting and grouting materials.

3. Miscellaneous Materials and Other Products: Obtain each of the following products specified in this Section from a single manufacturer:
   a. Waterproof membrane.

b. Crack isolation membrane.
c. Cementitious backer units.
d. Metal edge strips.

2.02 TILE PRODUCTS

A. Quarry Tile:

1. Standard Grade, ANSI A137.1, Section 5.3, Paver Tile.

2. Types: Natural clay paver tile as follows:
   a. Hexagonal: Either nominal eight inches or nominal six inches across flats by 3/4 inch thick; flat face, cushion (not square) edges.
   b. Base: 8-inch by 12-inch by 3/4 inch thick.
   c. Stair treads and risers: Bullnose tread, sizes as shown.

3. Color and Flash: Deep red color with factory-applied flash, matching samples on file with the Engineer. Make flashing natural in appearance across each paver unit; not linear, paint-like, or streaked; and with coverage varying from 10-percent to 50-percent of unit face area.

4. Abrasive Hardness: 50 or greater, ASTM C501.

5. Face of Tile: Unglazed, slip-resistant wearing surface integral with body of tile. Furnish tiles with or without embedded abrasive aggregate, as required to provide the specific minimum slip resistance specified below for each area of work.

6. Backs: Raised pattern.

7. Compressive Strength: 8,000-psi, minimum.

8. Slip Resistance: Minimum dynamic coefficients of friction (DCOF) as required by the ADA, tested in accordance with ANSI A137.1/ ANSI A326.3, but not less than the following:
   a. Level surfaces: 0.42 wet and dry.
   b. Ramps (slope greater than 1:20): 0.65 wet and dry.
   c. Stair treads: 0.65 wet and dry.

9. Water Absorption: 0.5 percent to 3.0 percent, ASTM C373

10. Dimensional Tolerances:
    a. Thickness: 0.040 inch maximum range of thickness, ASTM C499.
    b. Facial Dimensions: 3.0 percent maximum facial-dimension variation, maximum 1.5-percent range of facial dimension variation; ASTM C499.
    c. Warpage: 1.0 percent maximum along any edge, 0.75-percent maximum on either diagonal; ASTM C485.

B. Truncated Dome Quarry Tile:

1. Standard Grade, ANSI A137.1, Section 5.3, Paver Tile (not quarry tile).

2. Types: Natural clay paver tile as follows:
   a. Domed Form: Re-pressed tile to produce ADA-compliant raised domes.
      1) Nominal six-inch square by 1/2-inch thick at base of domes; square edges; actual measurement maximum 5-3/4 inch by 5-3/4 inch.
      2) Produce two projecting dome patterns, Style A and Style B, which are required to make a consistent ADA-required pattern for the detectable warning surface as shown.
   b. Flat Form: Nominal six-inch square tile by 1/2-inch thick; flat face, square edges; actual measurement maximum 5-3/4 inch by 5-3/4 inch.

3. Face of Tile: Unglazed, slip-resistant wearing surface integral with body of tile. Furnish tiles with or without embedded abrasive aggregate, as required to provide the specific minimum slip resistance specified below for each area of work.

4. Backs: Raised pattern.
5. Compressive Strength: 8,000-psi, minimum.
6. Slip Resistance: Minimum static coefficients of friction as required by the ADA, tested in accordance with ANSI A137.1/ ANSI A326.3, but not less than the following:
   a. Level surfaces: 0.42 wet and dry.
7. Color and Flash: Deep red color with factory-applied flash, matching samples on file with the Engineer. Make flashing natural in appearance across each paver unit; not linear, paint-like, or streaked; and with coverage varying from 10-percent to 50-percent of unit face area.
8. Abrasive Hardness: 50 or greater, ASTM C501.
9. Water Absorption: 0.5 percent to 3.0 percent, ASTM C373
10. Dimensional Tolerances:
    a. Thickness: 0.040 inch maximum range of thickness, ASTM C499.
    b. Facial Dimensions: 3.0 percent maximum facial-dimension variation, maximum 1.5-percent range of facial dimension variation; ASTM C499.
    c. Warpage: 1.0 percent maximum along any edge, 0.75-percent maximum on either diagonal; ASTM C485.

C. Tile Mortar:

1. Type 1: Latex-portland cement mortar, ANSI A118.4.
2. Type 2 (polyurethane adhesive): One-part or two-part polyurethane adhesive for exterior use, complying with the requirements of ASTM C836 and ANSI A136.1, with the following additional minimum requirements:
   a. Shear strength, conditioned, dry; ANSI A136.1: 80 psi, no bond breakage.
   b. Shear strength, conditioned, after water immersion; ANSI A136.1: 90 psi, no bond breakage.
   c. Shear strength after accelerated aging; ANSI A136.1: 150 psi, no bond breakage.
   d. Tensile Bond Strength: 350 psi minimum, for adhesive and for cohesive bond failure.
   e. Viscosity: Non-sag, trowelable. If necessary to maintain viscosity at higher ambient temperatures, provide thickening agent which will not reduce required properties below the requirements.
   f. Flammability When Cured: Noncombustible.
   g. Primer: As recommended by manufacturer.
   h. Sources: Subject to compliance with requirements, use one of the following or equal:
      1) FX-552 Tile Adhesive by Fox Industries, Baltimore, MD, 301/243-8856.
      2) Hydroment Ultra-Set by Bostik Division of Emhart, Huntington Valley, PA, 800/523-6530.
      3) Planicrete-W by MAPEI U.S.A., Elk Grove Village, IL, 800/426-2734.

D. Epoxy Mortar and Grout: ANSI A118.3.

E. Tile Grout:

1. Latex-portland-cement grout, ANSI A118.6.
2. Commercial portland-cement grout, presanded and pigmented. For narrow joints, grade sand to maximum sieve size as required to ensure full joints.
3. Latex manufactured or recommended by mortar and grout manufacturer; included in factory dry-mix or field-mixed with gauging liquid.
4. Color matching color of paver tile.

F. Polyurethane Sealant:

1. ASTM C920, Type M, Grade P or Grade NS as required for slope, Class 25, Use T.

2. Color matching grout color when moist.

3. Primer and joint cleaner: Use products recommended by sealant manufacturer, unless sealant manufacturer recommends against using primer and joint cleaner.

G. Sealant Backup Material: As recommended by the sealant manufacturer, and as required in Section 07 92 00.

H. Expansion Joint Assembly: Sections 07 95 00 and 07 95 13.

I. Premolded Expansion-Joint Filler: AASHTO M153, Type I.

J. Concrete Overlay: Section 03 30 00, Class 5000 concrete, pea gravel course aggregate 1/4-inch minimum to 3/8-inch maximum.

K. Mortar Bed for Bases: ANSI A108.1C.

L. Welded Steel-Wire Fabric: ASTM A185, size as shown.

M. Bond Breaker: Polyethylene sheeting, ASTM C171, minimum 0.004-inch thick.

N. Threshold:

1. Stone Type: Granite, complying with ASTM C615.

2.03 SETTING MATERIALS

A. Portland Cement Mortar (Thickset) Installation Materials: ANSI A108.02.

1. Cleavage Membrane: Asphalt felt, ASTM D226, Type I (No. 15); or polyethylene sheeting, ASTM D4397, 4.0 mils thick.

2. Reinforcing Wire Fabric: Galvanized, welded-wire fabric, 2 by 2 inches by 0.062 inch in diameter; comply with ASTM A185 and ASTM A82 except for minimum wire size.

3. Expanded Metal Lath: Diamond-mesh lath complying with ASTM C847.
   a. Base Metal and Finish for Interior Applications: Uncoated or zinc-coated (galvanized) steel sheet, with uncoated steel sheet painted after fabrication into lath.
   b. Base Metal and Finish for Exterior Applications: Zinc-coated (galvanized) steel sheet.
   c. Configuration over Studs and Furring: Flat.
   d. Configuration over Solid Surfaces: Self furring.
   e. Weight: [2.5 lb/sq. yd.] [3.4 lb/sq. yd.].

4. Latex Additive: Manufacturer's standard water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed.

B. Dry-Set Portland Cement Mortar (Thinset): ANSI A118.1.

1. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.1.

C. Latex-Portland Cement Mortar (Thinset): ANSI A118.4.

1. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.

2. Provide prepackaged, dry-mortar mix combined with [acrylic resin] [or] [styrene-butadiene-rubber] liquid-latex additive at Project site.

3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.4.

D. Medium-Bed, Latex-Portland Cement Mortar: Comply with requirements in ANSI A118.4. Provide product that is approved by manufacturer for application thickness of [5/8 inch] <Insert value>.

1. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.

2. Provide prepackaged, dry-mortar mix combined with [acrylic resin] [or] [styrene-butadiene-rubber] liquid-latex additive at Project site.

E. Water-Cleanable, Tile-Setting Epoxy: ANSI A118.3, with a VOC content of 65 g/L or less.

F. Organic Adhesive: ANSI A136.1, Type I**,** with a VOC content of 65 g/L or less.

2.04 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10, consisting of white or gray cement and white or colored aggregate as required to produce color indicated.

B. Standard Cement Grout: ANSI A118.6.

C. High-Performance Tile Grout: ANSI A118.7.

1. Polymer Type: Ethylene vinyl acetate or acrylic additive, in dry, redispersible form, prepackaged with other dry ingredients.

2. Polymer Type: [Acrylic resin] [or] [styrene-butadiene rubber] in liquid-latex form for addition to prepackaged dry-grout mix.

D. Water-Cleanable Epoxy Grout: ANSI A118.3, with a VOC content of 65 g/L or less.

2.05 MISCELLANEOUS MATERIALS

A. Trowelable Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Metal Edge Strips: Angle or L-shaped, height to match paver tile and setting-bed thickness, metallic or combination of metal and PVC or neoprene base, designed specifically for flooring applications; [half-hard brass] [white zinc alloy] [nickel silver] [stainless-steel, ASTM A666, 300 Series] exposed-edge material.

C. Protective Coating: Liquid grout-release coating that is formulated to protect exposed surfaces of paver tile against adherence of mortar and grout; compatible with paver , mortar, and grout products; easily removable after grouting is completed without damaging grout or paver tile; and recommended for use as temporary protective coating for paver tile.

1. Floor sealer complying with "Floor Sealer" Paragraph below may be used provided it is recommended by manufacturer for use as a grout release.

D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming paver tile and grout surfaces, specifically approved for materials and installations indicated by paver tile producers and grout manufacturers.

E. Floor Sealer: Colorless, stain- and slip-resistant sealer, not affecting color or physical properties of paver surfaces as recommended by paver tile producers for application indicated.

1. Sealers shall comply with requirements of FloorScore certification.

2.06 FABRICATION

A. Facial Dimensions of Paver Tiles with [Polished] [or] [Honed] Faces: Do not vary facial dimensions from specified dimensions by more than plus or minus 1/64 inch.

B. Facial Dimensions of Paver Tiles with [Sand-Rubbed] [Natural-Cleft] [or] [Thermal-Finished] Faces: Do not vary facial dimensions from specified dimensions by more than plus or minus 1/32 inch.

C. Thickness of Paver Tiles with [Polished] [Honed] [or] [Sand-Rubbed] Finish: Do not vary from specified thickness by more than plus or minus 1/32 inch.

D. Thickness of Paver Tiles with [Natural-Cleft] [or] [Thermal] Finish: Do not vary average thickness of each paver tile from specified thickness by more than plus or minus [1/32 inch].

E. Joint Surfaces: Except for specified beveled or eased edges if any, dress joint surfaces square for full depth of paver tile.

F. Backs of Tiles: Gage units by dressing backs of tiles smooth and flat. When tested with a 24-inch straightedge, gap shall not exceed 1/32 inch.

1. Natural-cleft paver need not be gaged if gap does not exceed 1/16 inch when tested with a 24-inch straightedge on backs of units.

G. Thresholds: Fabricate to size and profile as indicated or required to provide transition between adjacent floor finishes.

1. Bevel edges of thresholds at 1:2 slope, aligning lower edge of bevel with adjacent floor finish. Limit height of bevel to 1/2 inch or less, and finish bevel to match face of threshold.

2.07 MIXING MORTARS AND GROUT

A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.

B. Add materials, water, and additives in accurate proportions.

C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions where paver quarry tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify that substrates for setting paver quarry tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.

2. Verify that concrete substrates for paver quarry tile floors installed with [adhesives] [bonded mortar bed] [or] [thinset mortar] as required for the assembly indicated on the Drawings comply with surface finish requirements in ANSI A108.01 for installations indicated.

a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.

3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind paver tile has been completed.

4. Verify that joints and cracks in paver quarry tile substrates are coordinated with paver quarry tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Fill cracks, holes, and depressions in concrete substrates for paver quarry tile floors installed with [adhesives] [or] [thinset mortar] with trowelable patching compound specifically recommended by tile-setting material manufacturer.

B. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot toward drains.

C. Lay out paver quarry tile patterns by marking joint lines on substrates to verify joint placement at edges, corners, doors, and other critical elements.

1. Notify Architect and the Authority (WMATA) 21- days in advance of dates and times when layout will be done.

2. Obtain Architect's approval of layout before starting paver quarry tile installation.

D. Lay out paver quarry tiles on substrates or on an adjacent surface to establish placement of individual paver quarry tiles for balance of color and pattern variations.

1. Notify Architect seven days in advance of dates and times when layout will be done.

2. Architect may relocate specific paver quarry tiles with other paver quarry tiles of same type and will determine final location of each paver quarry tile within indicated patterns.

3. Identify each paver quarry tile with a temporary number marked on face of paver quarry tile that corresponds with an identical number marked on a layout drawing, and obtain Architect's approval before starting paver quarry tile installation.

E. Field-Applied Temporary Protective Coating: If indicated under paver quarry tile type or needed to prevent grout from staining or adhering to exposed paver quarry tile surfaces, precoat paver quarry tiles with continuous film of temporary protective coating, taking care not to coat unexposed paver quarry tile surfaces.

3.03 INSTALLATION

A. General Requirements:

1. Saw-cut paver tiles; breaking is prohibited.

2. Cutting domed tiles:
a. Plan layout of tiles to avoid cuts through domes of domed tiles to the greatest extent possible. If domes are cut grind the remaining area around the domes flush with the flat face of the tiles.

3. Install paver tile on level surfaces and ramps to meet specified static coefficients of friction.

4. Lay out work in advance for accurate spacing of surface bond patterns with uniform joint widths and for accurate locating of openings and movement-type joints.

5. Set truncated dome tiles, both domed and flat forms, with plastic joint spacers, except where such tiles are factory premounted at correct pattern and uniform spacing. Use two spacers along each side of a tile when field-setting. Remove spacers after mortar has fully cured, immediately prior to grouting.

6. Use grout of moist but stiff consistency, not a slurry. At narrow joints 1/4-inch and less, fill joints in two or more layers from bottom to top, applied before each layer cures, tooling each layer to compact grout and eliminate voids. At wider joints, fill in layers where needed and tool thoroughly to compact grout and prevent voids.

7. At sealant joints, execute work in accordance with Section 07 92 00.

B. Latex Portland-Cement Mortar Method:

1. Use for installation of paver-tile only in fully enclosed areas without exposure to weather, such as below-grade platforms and mezzanines except where epoxy mortar method is required.

2. TCNA Handbook Method F102 and ANSI A108.5, using tile mortar Type 1.

3. Obtain 100-percent contact with raised pattern back of tile with mortar by applying not less than 1/32-inch thick layer of mortar on back of each tile prior to placement in freshly notched mortar.

4. Grout installation: Use tile grout, ANSI A108.10.

C. Epoxy Mortar Method, ANSI A108.6:

1. Use for installation on metal surfaces.

2. Follow mortar manufacturer's recommendations.

D. Polyurethane Adhesive Method:

1. Use for installation of paver tile work wholly or partly exposed to weather, except where epoxy mortar method is required.

2. TCNA Handbook Method F102-98 and ANSI A108.4, using tile mortar Type 2 and as follows, except as otherwise necessary to comply with the printed instructions of the polyurethane-adhesive manufacturer.
   a. Prime substrate surface in accordance with manufacturer's instructions before applying polyurethane adhesive. Primer is required unless manufacturer provides written certification recommending against priming.
   b. Allow primer to dry for 12 hours before applying polyurethane adhesive, unless otherwise recommended in writing by manufacturer.
   c. Use the manufacturers recommended filler in the polyurethane adhesive so as to thicken adhesive sufficiently to accomplish the required application and also to accomplish filling the raised pattern back of tile with adhesive prior to placement. Adjust quantity of filler for the ambient temperature as instructed by manufacturer of adhesive.
   d. Obtain 100 percent coverage of substrate with the adhesive, which also functions as a membrane waterproofing, in accordance with ANSI A108.4.Use no more mortar than is necessary to obtain adhesion and coating of substrate. Remove excess mortar between tiles and from sides of joints to accommodate grouting for full depth of tile.
   e. Before allowing pedestrian traffic, allow set tiles to cure for 24 hours in temperatures between 60F and 90F. At temperatures between 50F and 60F, allow 72 hours.

3. Grout installation: Use tile grout; ANSI A108.10.

E. Portland Cement Mortar Bed Method:

1. Use for installation of paver tile base and wall finish.

2. TCA Handbook Method W221-98 and ANSI A108.1C and A108.10.

3. Back-butter tile with bond coat before setting.

3.04 MAINTENANCE MATERIALS

A. Furnish one-percent extra paver tile of each type and style.

B. Store tile in original containers, clearly marked as to contents and area of placement, in location directed.

3.05 PAVER TILE INSTALLATION

A. Comply with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in paver tile installation schedules. Comply with parts of the ANSI A108 series "Specifications for Installation of Ceramic Tile" that are referenced in TCNA installation methods specified in paver tile installation schedules, and apply to types of setting and grouting materials used.

1. For the following installations, follow procedures in the ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:
   a. Exterior paver tile floors.
   b. Paver tile floors in wet areas.
   c. Paver tile floors consisting of paver tiles 8 by 8 inches or larger.

B. Wipe backs of paver tiles with a damp cloth to remove dirt and dust before units are installed.

C. Extend paver tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

D. Accurately form intersections and returns. Perform cutting and drilling of paver tile without marring visible surfaces. Carefully grind cut edges of paver tile abutting trim, finish, or built-in items for straight aligned joints. Fit paver tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap paver tile.

E. Finish cut paver tile edges that will not be concealed by other construction by grinding and honing cut surfaces [and beveling edges] [and easing edges] to match factory-fabricated edges[unless otherwise indicated].

F. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.

G. Jointing Pattern: Lay paver tile in grid pattern unless otherwise indicated. Lay out paver tile work and center paver tile fields in both directions in each space or on each wall area. Lay out paver tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

1. Where adjoining paver tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.

2. Where paver tiles are specified or indicated to be whole integer multiples of adjoining paver tiles on floor, base, walls, or trim, align joints unless otherwise indicated.

H. Lay out paver tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

I. Match paver tiles within each space by selecting tiles to achieve uniformity of color and pattern. Reject or relocate paver tiles that do not match color and pattern of adjacent tiles.

J. Mix paver tiles to achieve a uniformly random distribution of color shadings and patterns.

K. Pattern Orientation: For paver varieties with directional pattern, orient pattern as indicated.

L. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and paver tile. Do not saw-cut joints after installing paver tiles.

1. Where joints occur in concrete substrates, locate joints in paver tile surfaces directly above them.

M. Paver Thresholds: Install paver thresholds in same type of setting bed as adjacent floor unless otherwise indicated.

1. At locations where mortar bed (thickset) would otherwise be exposed above adjacent floor finishes, set thresholds in latex-portland cement mortar (thinset).

2. Do not extend [cleavage membrane] [waterproofing] [or] [crack isolation membrane] under thresholds set in [dry-set portland cement] [or] [latex-portland cement] mortar. Fill joints between such thresholds and adjoining paver tile with elastomeric sealant.

N. Metal Edge Strips: Install [at locations indicated] [where exposed edge of paver tile flooring meets carpet, wood, or other flooring that finishes flush with top of paver tile] [where exposed edge of paver tile flooring meets carpet, wood, or other flooring that finishes flush with or below top of paver tile and no threshold is indicated].

3.06 CRACK ISOLATION MEMBRANE INSTALLATION

A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness and bonded securely to substrate.

B. Allow crack isolation membrane to cure before installing tile or setting materials over it.

3.07 INSTALLATION TOLERANCES

A. Variation from Plumb: For vertical joints, external corners, and other conspicuous lines, do not exceed 1/8 inch in 8 ft..

B. Variation in Level: For horizontal joints and other conspicuous lines, do not exceed 1/8 inch in 10 ft., or 1/2 inch.

C. Variation in Surface Plane of Flooring: Do not exceed 1/8 inch in 10 ft. from level or slope indicated when tested with a 10-ft. straightedge.

D. Variation in Plane between Adjacent Units (Lipping): Do not exceed the following differences between faces of adjacent units as measured from a straightedge parallel to paver tiled surface:

1. Units with Polished Faces: 1/64 inch.

2. Units with Honed Faces: 1/64 inch.

3. Units with Sand-Rubbed Faces: 1/32 inch.

4. Units with Thermal-Finished Faces: Depth of thermal finish or 3/16 inch, whichever is less.

5. Units with Natural-Cleft Faces: Depth of natural-cleft finish or 3/16 inch, whichever is less.

E. Variation in Joint Width: Do not vary joint thickness more than 1/16 inch or one-fourth of nominal joint width, whichever is less.

F. Hand-Tight Joints: Do not exceed 1/64 inch.

3.08 ADJUSTING AND CLEANING

A. Remove and replace tile that is damaged or that does not match adjoining paver tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.

B. Cleaning: On completion of placement and grouting, clean paver tile surfaces so they are free of foreign matter.

1. Remove grout residue from paver tile as soon as possible.

2. Clean grout smears and haze from paver tile according to paver tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners recommended by paver tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of paver tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3. Remove temporary protective coating by method recommended by coating manufacturer and acceptable to paver tile and grout manufacturer. Trap and remove coating to prevent drain clogging. Do not remove floor sealer if used as protective coating.

C. Apply sealer to cleaned paver tile flooring according to sealer manufacturer's written instructions.

3.09 PROTECTION

A. Protect installed paver tile floors with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by paver tile manufacturer, apply coat of neutral protective cleaner to completed paver tile walls and floors.

B. Prohibit foot and wheel traffic from paver tiled floors for at least seven days after grouting is completed.

C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from paver tile surfaces.

END OF SECTION

SECTION 09513

METAL PAN CEILINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes: Torsion-spring metal pan ceiling panels, ceiling suspension system, and load testing for ceilings:

1. Concealed grid designed to support metal pans.
2. Unperforated metal pans.
3. Perforated metal pans at recessed speaker locations.
4. Load testing for:
   a. New metal pan ceiling systems.
   b. Existing metal pan ceiling systems designated to remain.
5. Demonstration and training of Authority personnel.

B. Specified ceiling system is for use in areas that are protected from direct exposure to the elements, such as underground train rooms, mezzanines, passageways, pedestrian bridges, entry pavilions.

1.03 DEFINITIONS

A. LR: Light Reflectance coefficient.

1.04 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Complying with ASTM E1264 for Class A materials as determined by testing identical products according to ASTM E84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

B. Seismic Standard: Provide metal pan ceiling systems designed and installed to withstand the effects of earthquake motions according to the following:

1. ASCE/SEI 6, "Minimum Design Loads for Buildings and Other Structures", Section 9, "Wind Loads."
2. ASCE/SEI 7, "Minimum Design Loads for Buildings and Other Structures", Section 9, "Earthquake Loads."

C. Structural Performance: Torsion-spring metal pan ceiling system, shall withstand exterior exposure and the effects of gravity loads and the following loads and stresses without showing permanent deformation of ceiling system components and connections, including pans, torsion spring mounts, clip mounts and suspension system; noise or metal fatigue caused by vibration, deflection, and displacement of ceiling units; or permanent damage to fasteners and anchors.

1. Wind, Interior Air Movement Load: Uniform pressure 40 lbf/sq. ft. minimum, acting inward or outward.

2. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials.

3. Temperature Change (Range): 100 deg F.

4. Ceiling systems shall be tested for positive and negative air pressure; testing shall be consistent with the requirements of UL 580.

1.05 PREINSTALLATION CONFERENCE

A. Conduct conference at location to be determined by WMATA Project Manager.

B. Meet with the Authority Architect, metal pan ceiling Installer, metal pan ceiling manufacturer's representative.

C. Review methods and procedures related to metal pan ceiling testing and installation, including manufacturer's written instructions.

D. Perform training in ceiling system operation and maintenance for Contractor and WMATA maintenance personnel using installed mockup.

1.06 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples for Initial Selection: For components with factory-applied color and other decorative finishes.

C. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of size indicated below:

1. Metal Pans: Set of full-size samples of each type, finish, color, pattern, and texture. Show pan edge profile.

2. Exposed Suspension System Members, Moldings and Trim: Set of 12-inch long samples of each type, finish, and color.

D. Performance Data: For installed products indicated to comply with design loads and other criteria, include structural analysis and other analytical data signed and sealed by the qualified professional engineer responsible for their preparation.

E. Push/Pull Static and Dynamic Testing Plan: Submit documentation describing tests, methods and procedures to be performed on the laboratory and field mock-ups of metal pan ceiling system.

F. Installation and Inspection Checklist.

G. Shop and Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Verify dimensions of adjacent construction by field measurements before fabrication and indicate measurements on Shop Drawings.

2. Indicate panel locations, panel joints, shapes, and dimensions.
3. Ceiling suspension members, and suspension system components.
4. Method of attaching hangers to building structure.
5. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.
6. Ceiling-mounted items including lighting fixtures, diffusers, grilles, sprinklers, access panels, and special moldings.
7. Ceiling perimeter and penetrations through the ceiling; and trim and moldings.
8. Minimum Drawing Scale: 1/8 inch = 1 foot (1:96).

H. Qualifications Data:

1. Certifications for testing agency.
2. Certifications for ceiling system installers.

I. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each metal pan ceiling.

J. Evaluation Reports: For each metal pan ceiling and components and anchor and fastener type.

K. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

A. Maintenance Data: For products and finishes, to include in maintenance manuals.

B. Operations and Maintenance Manual: Include the following:

1. Ceiling manufacturer’s product data, installation and maintenance instructions.

1.08 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Materials and installation shall be in compliance with the applicable building code and other laws and regulations of the authorities having jurisdiction (AHJ).

B. Reference Standards and Specifications: Provide metal pan ceilings in compliance with the specified industry standards.

C. Source Limitations: For metal pan ceilings and suspension system, obtain each combination of metal pans and suspension systems from one source and from a single manufacturer with resources to provide products of consistent quality in appearance, physical properties, and performance.

D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum five years documented experience.

E. Installer Qualifications:

1. Installers shall have a minimum of five years documented experience specializing in the installation of the products specified in this Section.

2. Installers and supervisors shall be trained and approved by the metal pan ceiling system manufacturer. Training and approval of installers by the manufacturer shall occur prior to installation of metal pan ceiling system, including specified mock-ups.

F. Preconstruction Testing Service Qualifications: Engage an independent third party qualified testing agency to perform preconstruction testing on field mockups.

G. Testing Laboratory Qualifications: Accredited by National Voluntary Laboratory Accreditation Program or Nationally Recognized Testing Laboratory indicating that laboratory is capable of performing and certifying specified tests.

H. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockup of typical metal pan ceiling system assembly as shown on Drawings. Ceiling system area to be an area no fewer than three (3) contiguous metal panels, including edge conditions and field-cut panel conditions.

2. Testing shall be performed on mockups according to requirements in "Field Quality Control" Article.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Authority specifically approves such deviations in writing.

4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

I. Preconstruction Testing:

1. Use personnel, materials, and methods of construction that will be used at Project site.

2. Notify Architect and the Authority seven days in advance of the dates and times when field mockups will be tested.

3. Push/Pull Test: Perform push/pull tests on installed in-place mockup.

4. Remove and discard failed metal pan ceiling panels.

5. Field Testing: As specified in Part 3, Article Field Quality Control.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver metal pans, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Handle metal pans, suspension system components, and accessories carefully to avoid damaging units and finishes in any way.

1.10 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not install metal pan ceilings until wet work in spaces is complete and dry, work above ceilings is complete and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

2. In areas where existing ceiling assemblies are indicated to be removed, schedule demolition of existing ceiling panel system, installation of new metal pan ceiling system, and associated Work to ensure minimal exposure of building structural elements.

3. In areas where existing ceiling assemblies are indicated to be removed, do not leave exposed more than 25 percent of station ceiling area to be replaced.

1.11 COORDINATION

A. Coordinate layout and installation of metal pans and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, speakers, HVAC equipment, fire-suppression system, and partition assemblies.

1.12 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are clearly marked “Attic Stock,” and are packaged with protective covering for storage and identified with labels describing contents.

B. Metal Pans: Full-size units, equal to 2 percent of quantity installed.

C. Suspension System Components: Quantity of each grid and exposed molding and trim, equal to 2 percent of quantity installed.

PART 2 - PRODUCTS

2.01 METAL CEILING PANS

A. Metal Pan Standard: Provide manufacturer's standard metal pans of configuration indicated that comply with ASTM E1264 classifications as designated by types and light reflectances unless otherwise indicated.

B. Sheet Metal Characteristics: For metal components exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, roughness, stains, or discolorations.

1. Aluminum Sheet: Roll-formed aluminum sheet, complying with ASTM B209; alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

2.02 ALUMINUM PANS FOR METAL PAN CEILING

A. Aluminum Metal Pans:

1. Basis of Design Product: Provide Ceilings Plus; “Illusions”, or subject to compliance with specified requirements, one of the following:
   a. American Decorative Ceilings, “Visions 100.”
   b. Hunter Douglas Architectural Products, Inc., “Luxalon” Tile.
   c. Armstrong World Industries, Inc., “MetalWorks Torsion Spring”.

B. Classification: Units complying with ASTM E1264 for Type XX, other types described as unperforated aluminum facing (pan) units.

1. Pattern: none.

C. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.

1. Torsion-Spring-Hinged Pans: Designed to be securely retained in pre-slotted exposed suspension grid by torsion springs.

2. Panels shall have self-engaging wind locking clips at each corner along main suspension member.

3. Cutouts for light fixtures, sprinklers, and other ceiling devices shall be factory fabricated to the extent possible.

4. Panels shall be capable of providing individual downward access to ceiling area above suspension grid by pulling single panels downward without damaging or destroying the panels and/ or the ceiling system's integrity, and without disengaging adjacent panels. Installation shall provide concealed grid appearance when completed.

D. Pan Thickness: Not less than 0.040 inch, or greater if required, so that the panel deflection does not exceed L/360.

E. Pan Edge Detail: Square.

F. Pan Joint Detail: 1/8 inch (± 1/16 inch) space between pans, to allow for tool to disengage sliding clips.

G. Pan Size: 30 inches by 30 inches nominal.

H. Pan Face Finish: Painted in color selected from manufacturer's full range to closely match WMATA Architect's control sample.

I. LR: Not less than 0.70.

2.03 ALUMINUM PANS FOR METAL PAN CEILING AT RECESSED SPEAKER LOCATIONS

A. Aluminum Metal Pans:

1. Basis of Design Product: Provide Ceilings Plus; "Illusions", or subject to compliance with specified requirements, one of the following:
   a. American Decorative Ceilings, "Visions 100."
   b. Hunter Douglas Architectural Products, Inc., "Luxalon" Tile.
   c. Armstrong World Industries, Inc., "MetalWorks Torsion Spring".

B. Classification: Units complying with ASTM E1264 for Type XX, other types described as perforated aluminum facing (pan) units with no backing.

1. Pattern: Pattern C (perforated, small holes) arranged in diagonal alignment to pan edge, regularly spaced, as selected from manufacturer's full range.

C. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.

1. Torsion-Spring-Hinged Pans: Designed to be securely retained in pre-slotted exposed suspension grid by torsion springs. Torsion springs shall not be attached with pop rivets or other fastener that can be damaged by panel removal.

2. Panels shall have self-engaging wind locking clips at each corner along main suspension member.

3. Cutouts for light fixtures, sprinklers, and other ceiling devices shall be factory fabricated to the extent possible.

4. Panels shall be capable of providing individual downward access to ceiling area above suspension grid by pulling single panels downward without damaging or destroying the panels and/ or the ceiling system's integrity, and without disengaging adjacent panels. Installation shall provide concealed grid appearance when completed.

D. Pan Thickness: Not less than 0.040 inch.

E. Pan Edge Detail: Square.

F. Pan Joint Detail: 1/8 inch (± 1/16 inch) space between pans, to allow for tool to disengage sliding clips.

G. Pan Size: 30 inches by 30 inches nominal.

H. Pan Face Finish: Painted in color selected from manufacturer's full range to closely match WMATA Architect's control sample.

I. LR: Not less than 0.70.

2.04 METAL SUSPENSION SYSTEMS

A. Recycled Content: Provide products made from steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.

B. Metal Suspension System Standard: Provide manufacturer's standard aluminum suspension systems of types, structural classifications, and finishes indicated that comply with applicable ASTM C635 requirements.

C. Suspension Systems: Provide systems complete with carriers, runners, splice sections, connector clips, alignment clips, leveling clips, hangers, molding, trim, retention clips, load-resisting struts, and other suspension components required to support ceiling panels, panel-mounted light fixtures and other ceiling-supported construction up to 10 lbs./sf, and resist torsion and other forces.

D. Attachment Devices: Size for five times the design load indicated in ASTM C635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E1190, conducted by a qualified testing and inspecting agency. Provide a minimum of 2 per anchorage point, to prevent torsion.

E. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A641, Class 1 zinc coating, soft temper.

2. Stainless-Steel Wire: ASTM A580, Type 304, nonmagnetic.

3. Nickel-Copper-Alloy Wire: ASTM B164, nickel-copper-alloy UNS No. N04400.

4. Size: Select wire diameter so its stress at 3 times the hanger design load indicated in ASTM C635, Table 1, Direct Hung will be less than yield stress of wire, but provide not less than 0.135-inch- diameter wire.

F. Hanger Rods or Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

G. Angle Hangers: Angles with legs not less than 7/8 inch wide; formed with 0.04-inch- thick, galvanized-steel sheet complying with ASTM A653, G90 (Z275) coating designation; with bolted connections and 5/16-inch- diameter bolts.

H. Exposed Metal Edge Moldings and Trim: Provide exposed members as indicated or as required to comply with seismic requirements of authorities having jurisdiction, to conceal edges of and penetrations through ceiling, to conceal edges of pans and runners, for fixture trim and adapters, for fascia at changes in ceiling height, and for other conditions; of metal and finish matching metal pan ceiling units, unless otherwise indicated.

1. For Circular Penetrations of Ceiling and Curved Edge Trim: Fabricate edge moldings to diameter required to fit penetration exactly or follow profile exactly.

2.05 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. High-Humidity Finish: Comply with ASTM C635 requirements for "Coating Classification for Severe Environment Performance."

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.06 ALUMINUM FINISHES

A. Color-Coated Finish: Manufacturer's standard baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which metal pan ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of metal pan ceilings.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Measure each ceiling area and establish layout of metal pans to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width pans at borders, and comply with layout shown on reflected ceiling plans and Coordination Drawings.

3.03 INSTALLATION

A. Install metal pan ceiling system and accessories under supervision of metal pan ceiling system manufacturer's authorized representative to produce a rigid, firm installation that complies with performance requirements.

B. Install metal pan ceilings to comply with local seismic requirements, manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."

C. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved.
6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
8. Do not attach hangers to steel deck tabs.
9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
10. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.
11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

D. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with postinstalled anchors.

E. Install edge moldings and trim of type indicated at perimeter of ceiling area and where necessary to conceal edges of metal pans.

1. Apply sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.

2. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely.

3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

F. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

G. Cut metal pan units for accurate fit at borders and at interruptions and penetrations by other work through ceilings. Stiffen edges of cut units as required to eliminate evidence of buckling or variations in flatness exceeding referenced standards for stretcher-leveled metal sheet.

H. Install metal pans in coordination with suspension system and exposed moldings and trim.

1. For torsion-spring-hinged pans, position pans according to manufacturer's written instructions.

2. Align joints in adjacent courses to form uniform, straight joints parallel to room axis in both directions unless otherwise indicated.

3. Fit adjoining units to form aligned joints uniform and consistent width, without lippage.

3.04 SITE TESTS AND INSPECTIONS

A. Special Tests and Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Suspended ceiling system.

2. Hangers, anchors, and fasteners.

3. Metal pan ceiling panels.

B. Testing Agency: Engage a qualified nationally recognized testing laboratory or testing agency to perform tests and inspections.

C. Perform tests and inspections in accordance with metal ceiling system manufacturer using manufacturer’s approved tools and procedures.

D. Testing and inspecting of completed installations of panel ceiling hangers and anchors and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of panel ceiling hangers for the next area until test results for previously completed installations of panel ceiling hangers show compliance with requirements.

E. Push/Pull Test Area:

1. Perform tests on 10 percent of the total installed area of metal pan ceiling panels and suspension system.

2. Conduct tests on panel assemblies at intervals of every tenth (10th) panel, across the entire station platform, in both inbound and outbound track directions. The test panel

assembly shall include the 10th panel and the panels immediately to the right and to the left of the 10th panel.

F. Extent of Each Test Area: When installation of ceiling suspension systems on each floor or station platform/mezzanine level has reached 20 percent completion but no panels have been installed.

1. Within each test area, testing agency will select 1 of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf of tension; it will also select one of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbfof tension.
   a. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.

G. Test Procedures, Metal Panel Ceiling Grid:

1. At each area selected for testing, test each ceiling panel for correct installation of metal panel to ceiling grid. At each corner of ceiling panel, carefully and without damaging ceiling panel, perform pull test to verify that panel is securely attached to the ceiling grid.
2. Panel Lifting/Pulling Device: Vacuum suction cup panel lifter, manufacturer's standard portable lifting device for each type of panel required.
   a. Lifting/pulling device shall be capable of transferring the specified test loads uniformly over the face of metal panel.
3. Test Load: 125 pounds.
4. Rate of Application of Load: In accordance with test standard unless otherwise specified or indicated.
5. Duration: In accordance with test standard unless otherwise specified or indicated.
6. Undamaged panels failing test shall be reattached to ceiling grid in accordance with manufacturer’s instructions and shop drawings and retested.
7. Panels that are bent, warped, twisted, exhibit oil canning, or other damage as a result of the testing shall be replaced with new panels of the same type and color as the adjacent ceiling panels.
8. For panels failing tests, test all panels within area installed.

H. Ceiling grid, ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.

I. Reports:

1. Prepare test and inspection reports.
2. Prepare daily inspection and installation reports.

3.05 CLOSEOUT ACTIVITIES

A. Demonstration And Training:

1. Engage a factory-authorized service representative to train the Authority’s maintenance personnel to adjust, operate, and maintain metal pan ceiling system.

3.06 CLEANING

A. Clean exposed surfaces of metal pan ceilings, including trim and edge moldings after removing strippable, temporary protective covering, if any. Comply with manufacturer's written instructions for stripping of temporary protective covering, cleaning, and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.

END OF SECTION

SECTION 09920

FIELD PAINTING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing and applying paint at the site.
   1. Specific surfaces and areas which require field painting and required paint systems are listed in the schedule of painting.
   2. Unless an item is shown not to be field painted or specified otherwise paint it in accordance with these specifications.

B. Definitions:
   1. Paint: Includes primers and undercoaters, sealers, stains, paint, varnish, enamel, epoxy and special coatings.

C. Items Not Included In Field Painting:
   1. Stainless steel, ornamental metals, glass, resilient tile, ceramic tile, paving, acoustical tile, plastic laminate and similar items which are prefinished.
   2. Mill-, factory- and shop-applied primers and finishes.
   3. Corrosion-resistant structural steel, ASTM A242.
   4. High-strength structural corrosion-resistant steel shapes, plates and bars, ASTM A588.
   5. Galvanized-metal surfaces except fire stand pipes, unless exposed to public view.
   6. UL labels on fire-rated doors and frames.
   7. Precast or prestressed concrete with a sandblast finish, concrete sealer, or other special finish unless noted otherwise

D. Related Work Specified Elsewhere:
   1. Mill-, factory- and shop-applied prime and finish coats: Specified with the product.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Samples:
      a. Three each of each color and texture, with identification of materials keyed to those specified and application methods.
      b. Samples of paint scheduled for application to smooth finishes applied to 12-inch square hardboard or metal panels.
      c. Samples of paint scheduled for application to concrete masonry units applied to 16-inch square by two-inch thick panel of concrete masonry units, including one tooled masonry joint. Subdivide panel to define prime or filler, intermediate and finish coats.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. FS: TT-E-489, TT-E-490, TT-E-509, TT-F-336, TT-F-1098, TT-P-19, TT-P-29, TT-P-636, TT-P-641, TT-P-645, TT-P-650, TT-P-664, TT-P-1510, TT-P-001984, TT-S-71, TT-S-300, TT-V-86, TT-V-119.
   3. ASME: A13.1.
   4. ANSI: Z535.1.

5. ASTM: A242, A588, B117, C476, C920.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to the jobsite in their original unopened containers clearly labeled with the manufacturer's name and brand designation, referenced specification number and type, as applicable.

B. Store products in an approved ventilated dry area, protect from contact with soil and from exposure to the elements. Always keep products dry. Do not allow paint to freeze.

C. Handle products in a manner that will prevent breakage of containers and damage to products.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not apply paint to non-protected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible.
2. Do not apply exterior paint when the temperature is below 40F or expected to fall below this temperature. Do not apply interior paint when the temperature is lower than 60F or expected to fall below this temperature.
3. Avoid painting steel which is at a temperature which can cause blistering, porosity, or otherwise be detrimental to the life of the paint. When paint is applied in hot weather or thinned in cold weather ensure that the specified thickness of paint coating is obtained.
4. Do not apply paint in rain, wind, snow, fog or mist or when the steel surface temperature is below the dew point, resulting in condensation of moisture.
5. Do not apply interior paint when, in the Engineer's opinion, satisfactory results cannot be obtained due to high humidity and excessive temperature; however, failure of the Engineer to notify the Contractor of the conditions will not relieve the Contractor of responsibility to produce satisfactory results.

PART 2 - PRODUCTS

2.01 GENERAL:

A. To the maximum extent practicable, use the materials of one manufacturer throughout the project. No claims as to the suitability of a material specified, or of inability to produce first-class work with these materials, will be considered unless such claims are made in writing and submitted with the Contractor’s Bid Proposal.

B. Provide a primer suitable for each substrate type and which is manufactured or recommended by the paint manufacturer as part of a complete painting system.

C. Previously Primed Surfaces:
1. If surfaces have been primed off-site at the mill, factory or shop, omit specified primer, but only if the off-site primer is acceptable to the paint system manufacturer for best performance of the specified paint system.
2. For touch-up of off-site primer, use primer of the same composition as the mill, factory or shop primer.

D. VOC Requirements: Provide products in compliance with local volatile organic compound regulations. If the listed product of a manufacturer does not comply, provide an accepted equivalent product which does comply.

E. Colors:
1. Prior to beginning work, the Contractor will be furnished sample color chips and a Color and Material Schedule for surfaces to be painted.
2. Match the colors of the chips and submit samples before proceeding. Label samples for surface finishes such as satin, flat or gloss as listed in the Color and Material Schedule.
3. Tint each coat of paint slightly lighter or darker than the preceding coat or the finish coat.
4. Final approval of colors will be made by the Engineer on samples applied on the job.
5. Safety Colors: Items specified to be safety colors, e.g. OSHA red (safety red) and ANSI orange, to be in compliance with ANSI Z535.1, Safety Color Code.

F. Listed materials are a guide to quality intended. Substitute materials and paint systems acceptable to the Engineer, as an equal or of superior quality for each intended use, may be used in the work at no additional cost to the Authority.

G. Accessory Materials:
1. General: Provide miscellaneous materials and accessories, whether listed or not, as necessary to complete the work in an approved manner.
2. Caulk: Single-component, chemically curing, synthetic rubber, non-sag, ASTM C920, Type S, NS, Class 25.
3. Spackling compound: Ready-mixed type, U.S. Gypsum Ready-Mixed Joint Compound - Topping, ASTM C476 or equal.
4. Thinner: As recommended by the paint manufacturer.

2.02 EXTERIOR PAINTING SYSTEMS:

A. Exterior Paint Schedule: Provide the paint systems scheduled below for the various substrates, as indicated. Provide a complete paint system by one manufacturer for each substrate. Unless otherwise indicated, provide the following:
1. Concrete and masonry (except concrete masonry units): Acrylic, flat.
2. Concrete masonry units: Acrylic, flat.
3. Portland cement plaster (soffits): Acrylic, flat.
4. Ferrous metal: Silicone-alkyd, semigloss.
5. Zinc-coated metal: Silicone-alkyd, semigloss.
6. Aluminum: Alkyd, semigloss.
7. Wood: Acrylic-enamel, semigloss.
8. Mechanical and electrical items (not finish painted): See substrate materials above.

B. Concrete, Masonry (except concrete masonry units), and portland cement plaster - Acrylic, Flat: Two coats with total dry film thickness not less than 2.5 mils.
1. Undercoat: Quick-drying, flat, acrylic paint for use on the exterior over concrete, masonry, and portland cement plaster (FS TT-P-19):
a. Con-Lux: Mason-Plex 800 Series.
b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
2. S-W:A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.Finish Coat: Quick-drying, flat, acrylic paint for use on the exterior over concrete, masonry, and portland cement plaster (FS TT-P-19)
a. Con-Lux: Mason-Plex 800 Series.
b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.

d. S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.

C. Concrete Masonry Units - Acrylic, Flat: Two coats over block filler with total dry film thickness not less than 2.5 mils, excluding the block filler.

1. Block Filler: High performance latex block filler used for filling open textured concrete masonry block before application of top coats:
   a. Con-Lux: Block-Plex 85 White.
   b. Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
   c. Moore: Moorcraft Block Filler #145.
   d. S-W: Heavy-Duty Block Filler B42W46.
2. Undercoat: Quick-drying, flat, acrylic paint for use on the exterior over concrete masonry block (FS TT-P-19):
   a. Con-Lux: Mason-Plex 800 Series.
   b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
   c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
   d. S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.
3. Finish Coat: Quick-drying, flat, acrylic paint for use on the exterior over concrete masonry block (FS TT-P-19):
   a. Con-Lux: Mason-Plex 800 Series.
   b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
   c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
   d. S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series

D. Ferrous Metal - Silicone-Alkyd, Semigloss: Two coats over primer.(Apply a second coat of primer on steel which is at grade, at slab, or passing through floor slabs. Apply to a uniform line six inches above top of grade or slab.)

1. Primer: Lead and chromate-free high solids primer which chemically inhibits rusting and is recommended by the manufacturer for application to steel which has been prepared in accordance with SSPC SP2. Rated 10 (less than 0.01% surface rusting) when tested in accordance with ASTM B117 for 500 hours. Exceeds performance requirements of FS TT-P-636:
   a. Con-Lux: Rust Arrestor 50.
   b. S-W: Kem Kromik Universal Metal Primer B50NZ6.
   c. Tnemec: Series P10.
2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over specified primer for application of silicone-alkyd finish coat:
   a. Con-Lux: Ferrox Primer.
   b. S-W: Silicone Alkyd Enamel B-56 Series.
   c. Tnemec: Series 23 Enduratone.
3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
   a. Con-Lux: Steel-Master 9500 Series.
   b. S-W: Silicone Alkyd Enamel B-56 Series.
   c. Tnemec: Series 82 Silicone-Alkyd Enamel.

E. Ferrous Metal - Alkyd, Semigloss: Two coats over primer (primer is not required on shop-primed items):

1. Primer: Quick-drying, rust-inhibiting primer for priming ferrous metal under alkyd enamel (FS TT-P-664):
   a. Con-Lux: Ferrox Primer, 25 Red.
   b. Devoe: 41820 Bar-Ox Alkyd Shop/Field Primer.
   c. Moore: Ironclad Retardo Rust-Inhibitive Paint #163.
   d. S-W: Kem Kromik Metal Primer B50N2/B50W1.

2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated ferrous metal (FS TT-E-489, Class A):
   a. Con-Lux: Enamelite Semi-Luster Series
   b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
   c. Moore: Impervo Enamel #133.
   d. S-W: Industrial Enamel, B-54Z Series.
3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated ferrous metal (FS TT-E-489, Class A):
   a. Con-Lux: Enamelite Semi-Luster Series.
   b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
   c. Moore: Impervo Enamel #133.
   d. S-W: Industrial Enamel, B-54Z Series.

F. Zinc-Coated Metal - Silicone-Alkyd, Semigloss: Two coats over factory-applied primer:
1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following.
   a. Con-Lux: Bond-Plex 46 Barrier Green.
   b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
   c. Moore: Ironclad Galvanized Metal Latex Primer #155.
   d. S-W: Industrial Water Based Acrylic Paint B42W110.
2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over factory-applied primer for application of silicone-alkyd finish coat:
   a. Con-Lux: Ferrox Primer.
   b. S-W: Silicone Alkyd Enamel B-56 Series.
   c. Tnemec: Series 23 Enduratone.
3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
   a. Con-Lux: Steel-Master 9500 Series.
   b. S-W: Silicone Alkyd Enamel B-56 Series.
   c. Tnemec: Series 82 Silicone-Alkyd Enamel.

G. Zinc-Coated Metal - Alkyd, Semigloss: Two coats over primer:
1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following:
   a. Con-Lux: Bond-Plex 46 Barrier Green.
   b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
   c. Moore: Ironclad Galvanized Metal Latex Primer #155.
   d. S-W: Industrial Water Based Acrylic Paint B42W110.
2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated zinc-coated (galvanized) metal (FS TT-E-489, Class A):
   a. Con-Lux: Enamelite Semi-Luster Series.
   b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
   c. Moore: Impervo Enamel #133.
   d. S-W: Industrial Enamel, B-54Z Series.
3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated zinc-coated (galvanized) metal (FS TT-E-489, Class A):
   a. Con-Lux: Enamelite Semi-Luster Series.
   b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
   c. Moore: Impervo Enamel #133.
   d. S-W: Industrial Enamel, B-54Z Series.

H. Aluminum - Alkyd, Semigloss: Two coats over primer:
1. Primer: Alkyd-type zinc chromate primer used for priming aluminum under alkyd enamels (FS TT-P-645), or one of the following.
   a. Con-Lux: Bond-Plex 46 Barrier Green.

b. Devoe: 41839 Bar-Ox Zinc Chromate Primer.
c. Moore: Ironclad Retardo Rust Inhibitive Paint #163.
d. S-W: Zinc Chromate Primer B50Y1.

2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated aluminum (FS TT-E-489, Class A):
   a. Con-Lux: Enamelite Semi-Luster Series.
   b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
   c. Moore: Impervo Enamel #133.
   d. S-W: Industrial Enamel, B-54Z Series.
3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated aluminum (FS TT-E-489, Class A):
   a. Con-Lux: Enamelite Semi-Luster Series
   b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
   c. Moore: Impervo Enamel #133.
   d. S-W: Industrial Enamel, B-54Z Series.

I. Wood - Acrylic Enamel, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils:
1. Primer: Exterior alkyd or latex primer made for use on wood under an acrylic enamel (FS TT-P-001984):
   a. Con-Lux: Wood-Plex 700 Primer.
   b. Devoe: 1102 All-Weather Exterior Alkyd House Paint Primer.
   c. Moore: Moorwhite Primer #100.
   d. S-W: A-100 Exterior Latex Wood Primer
2. Undercoat: Semigloss, waterborne, exterior, acrylic enamel made for use as an undercoat over a primer on wood under an acrylic enamel (FS TT-P-1510):
   a. Con-Lux: Weather-Plex 700 Series
   b. Devoe: 17XX Wonder-Shield Semi-Gloss Exterior Acrylic latex House and Trim Paint.
   c. Moore: MoorGlo Latex House and Trim Paint #096.
   d. S-W: A-100 Exterior Latex Satin.
3. Finish Coat: Semigloss, waterborne, exterior, acrylic enamel made for use as a finish coat over an acrylic enamel (FS TT-P-1510):
   a. Con-Lux: Weather-Plex 700 Series.
   b. Devoe: 17XX Wonder-Shield Semi-Gloss Exterior Acrylic latex House and Trim Paint.
   c. Moore: MoorGlo Latex House and Trim Paint #096.
   d. S-W: A-100 Exterior Latex Satin.

J. Wood - Stained-Varnish: Two coats over sealer over stain plus filler on open-grain wood. Wipe filler before applying first varnish coat.
1. Stain Coat: Match interior stained-varnish finish.
2. Sealer: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119), thinned as recommended by manufacturer:
   a. Con-Lux: Imperial 71 Spar Varnish.
   b. Devoe: 87 Spar Varnish.
   c. Moore: Impervo 440 Spar Varnish.
   d. S-W: Exterior Varnish A67V4
3. Undercoat: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119):
   a. Con-Lux: Imperial 71 Spar Varnish.
   b. Devoe: 87 Spar Varnish.
   c. Moore: Impervo 440 Spar Varnish.
   d. S-W: Exterior Varnish A67V4.
4. Finish Coat: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119):

a. Con-Lux: Imperial 71 Spar Varnish.
b. Devoe: 87 Spar Varnish.
c. Moore: Impervo 440 Spar Varnish.
d. S-W: Exterior Varnish A67V4.

2.03 INTERIOR PAINTING SYSTEMS:

A. Interior Paint Schedule: Provide the paint systems scheduled below for the various substrates, as indicated. Provide a complete paint system by one manufacturer for each substrate. Unless otherwise indicated, provide the following:
1. Concrete and masonry (except concrete masonry units and concrete floors): Latex, flat.
2. Concrete masonry units (except ground-faced CMU, which is to be left unpainted): Latex, flat.
3. Concrete floors: Epoxy, gloss, with anti-slip aggregate.
4. Gypsum plaster, veneer plaster, and GFRG: Latex, eggshell.
5. Acoustical plaster: Unpainted.
6. Gypsum board: Latex, flat.
7. Woodwork: Stained-varnish finish, except alkyd, semigloss where painted is indicated.
8. Ferrous metal:
   a. Exposed steel structure: Silicone-alkyd, semigloss.
   b. Other interior ferrous metal: Alkyd, semigloss.
9. Zinc-coated metal: Alkyd, semigloss; except silicone-alkyd where part of ferrous metal assemblies painted with silicone-alkyd.
10. Non-ferrous metal: Alkyd, semigloss.
11. Cotton and canvass covering over insulation: Latex, flat.
12. Mechanical and electrical items (not finish painted): See substrate materials above.

B. Concrete and Masonry (Except concrete masonry units) - Latex, Flat: Two coats.
1. Undercoat: Flat latex-based paint made for use as an undercoat over concrete and masonry under a flat latex paint (FS TT-P-29):
   a. Con-Lux: Jet-Plex 495 Primer.
   b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
   c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
   d. S-W: Pro-Mar 200 Latex Flat B30W200.
2. Finish Coat: Flat latex-based paint made for use as a flat finish over concrete and masonry (FS TT-P-29):
   a. Con-Lux: Wall-Plex 400 Series.
   b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
   c. Moore: Regal Wall Satin 215.
   d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

C. Concrete and Masonry (Except concrete masonry units) - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 3.5 mils.
1. Primer: Flat latex-based paint made for use as a primer over concrete and masonry under an odorless alkyd enamel (FS TT-P-29):
   a. Con-Lux: Wall-Plex 400 Series.
   b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
   c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
   d. S-W: Pro-Mar 200 Latex Flat B30W200.
2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a primer on concrete or masonry under an odorless alkyd enamel:
   a. Con-Lux: Enamel Underbase 54 White.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.

c. Moore: Moore's Alkyd Enamel Underbody 217.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on concrete and masonry (FS TT-E-509):
a. Con-Lux: Satin-Lite 900 Series
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Satin Impervo Enamel 235.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

D. Concrete and Masonry (Except concrete masonry units) - Epoxy, Semi-Gloss: Two coats over primed surface.
1. Primer: Sealer made for use as a primer over masonry wall surfaces and under an epoxy enamel:
a. Con-Lux: Jet-Plex 495 Primer.
b. Duron: Acrylic Enamel Undercoater.
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: Kem Cati-Coat Epoxy Filler/Sealer.
2. Undercoat: Epoxy enamel undercoat made for use under a semi-gloss epoxy enamel:
a. Con-Lux: Epolon Semi-Luster Series.
b. Duron: Polyamide Epoxy.
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: Heavy Duty Epoxy.
3. Finish Coat: Semi-gloss epoxy enamel finish coat made for use over an epoxy enamel undercoat:
a. Con-Lux: Epolon Semi-Luster Series.
b. Duron: Polyamide Epoxy.
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: Heavy Duty Epoxy.

E. Concrete Masonry Units (Except ground-faced CMU, which is to be left unpainted) - Latex, Flat: Two coats over filled surface.
1. Block Filler: High-performance latex block filler made for use for filling open textured concrete masonry block before application of top coats (FS TT-F-1098):
a. Con-Lux: Block-Plex 85 White.
b. Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
c. Moore: Moorcraft Interior and Exterior Block Filler 173.
d. S-W: Heavy-Duty Block Filler B42W46.
2. Undercoat: Flat latex-based paint made for use as an undercoat over filled concrete masonry block under a flat latex paint (FS TT-P-29):
a. Con-Lux: Wall-Plex 400 Series.
b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
d. S-W: Pro-Mar 200 Latex Flat B30W200.
3. Finish Coat: Flat latex-based Paint made for use as a flat finish over filled concrete masonry block (FS TT-P-29):
a. Con-Lux: Wall-Plex 400 Series.
b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
c. Moore: Regal Wall Satin 215.
d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

F. Concrete Masonry Units (Except ground-faced CMU, which is to have clear anti-graffiti coating over unfilled surface) - Alkyd, Semigloss: Two coats over filled surface with total dry film thickness not less than 3.5 mils, excluding filler coa
1. Block Filler: High-performance latex block filler made for use for filling open textured concrete masonry block before application of top coats (FS TT-F-1098):

a. Con-Lux: Block-Plex 85 White.
b. Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
c. Moore: Moorcraft Interior and Exterior Block Filler 173.
d. S-W: Heavy-Duty Block Filler B42W46.

2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a block filler on concrete masonry block under an odorless alkyd enamel:
a. Con-Lux: Enamel Underbase 54 White.
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Alkyd Enamel Underbody 217.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a block filler and undercoat on concrete masonry block (FS TT-E-509):
a. Con-Lux: Satin-Lite 900 Series.
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Satin Impervo Enamel 235.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

G. Concrete Masonry Units (Except ground-faced CMU, which is to have clear anti-graffiti coating over unfilled surface) - Epoxy, Semi-Gloss: Two coats over filled surface.
1. Filler:Filler made for use as a primer over masonry wall surfaces and under an epoxy enamel:
a. Con-Lux: Jet-Plex 495 Primer; or Block-Plex Block Filler.
b. Duron: Acrylic Enamel Undercoater; or Block Kote Latex Block Filler.
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel; or Moorcraft Interior and Exterior Block Filler.
d. S-W: Kem Cati-Coat Epoxy Filler/Sealer; or Heavy Duty Block Filler.

2. Undercoat: Epoxy enamel undercoat made for use under a semi-gloss epoxy enamel:
a. Con-Lux: Epolon Semi-Luster Series.
b. Duron: Polyamide Epoxy.
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: Heavy Duty Epoxy.

3. Finish Coat: Semi-gloss epoxy enamel finish coat made for use over an epoxy enamel undercoat:
a. Con-Lux: Epolon Semi-Luster Series.
b. Duron: Polyamide Epoxy
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: Heavy Duty Epoxy.

H. Concrete Floor Surfaces - Epoxy, Gloss: Two coats over primer, with anti-slip aggregate in finish coat:
1. Primer: Epoxy sealer made for use as a primer over concrete floor surfaces and under an epoxy enamel:
a. Con-Lux: None required.
b. Duron: Acrylic Enamel Undercoater
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: ArmorSeal 3300LV Epoxy Primer/Sealer.

2. Undercoat: Epoxy enamel undercoat made for use over an epoxy primer and under a gloss epoxy enamel:
a. Con-Lux: Epolon Series with Epolon 145 Reducer.
b. Duron: Polyamide Epoxy.
c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
d. S-W: ArmorSeal 1000HS.

3. Finish Coat: Epoxy enamel finish coat made for use over an epoxy enamel undercoat:
   a. Con-Lux: Epolon Series with anti-slip aggregate.
   b. Duron: Polyamide Epoxy with anti-slip aggregate.
   c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel with anti-slip aggregate.
   d. S-W: ArmorSeal 1000HS with anti-slip aggregate.

I. Gypsum Plaster, Veneer Plaster, and GFRG - Latex, Eggshell (Low-Gloss): Two coats over primer; plus sealer for GFRG.
1. Sealer for GFRG: Same as primer coat, to expose hot spots and facilitate sanding to remove "fiber bloom".
2. Primer: Flat latex-based paint made for use as a primer on plaster under an eggshell latex paint (FS TT-P-29):
   a. Con-Lux: Jet-Plex 495 Primer.
   b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
   c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
   d. S-W: Wall and Wood Primer B99WZ2.
3. Undercoat: Eggshell latex paint made for use over a primer on plaster (Performance requirements of FS TT-P-29):
   a. Con-Lux: Luster-Plex 2000 Series.
   b. Devoe: 34XX Wonder-Tones Interior Latex Eggshell Enamel.
   c. Moore: Regal AquaVelvet 319.
   d. S-W: Pro-Mar 200 Latex Eggshell Enamel B20W200 Series.
4. Finish Coat: Eggshell latex paint made for use over a primer and undercoat on plaster (Performance requirements of FS TT-P-29):
   a. Con-Lux: Luster-Plex 2000 Series.
   b. Devoe: 34XX Wonder-Tones Interior Latex Eggshell Enamel.
   c. Moore: Regal AquaVelvet 319.
   d. S-W: Pro-Mar 200 Latex Eggshell Enamel B20W200 Series.

J. Gypsum Plaster, Veneer Plaster, and GFRG - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils; plus sealer for GFRG.
1. Sealer for GFRG: Same as primer coat, to expose hot spots and facilitate sanding to remove "fiber bloom".
2. Primer: Flat latex-based paint made for use as a primer on plaster under an odorless alkyd enamel (FS TT-P-29):
   a. Con-Lux: Jet-Plex 495 Primer.
   b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
   c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
   d. S-W: Wall and Wood Primer B99WZ2.
3. Undercoat: Enamel undercoat made for use as an undercoat over a primer on plaster under an odorless alkyd enamel:
   a. Con-Lux: Enamel Underbase 54 White.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel
   c. Moore: Moore's Alkyd Enamel Underbody 217.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series
4. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on plaster (FS TT-E-509):
   a. Con-Lux: Satin-Lite 900 Series.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
   c. Moore: Moore's Satin Impervo Enamel 235.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

K. Gypsum Board - Latex, Flat: 1 coat over primer.

1. Primer: Latex-based white primer made for use on interior gypsum board under a flat latex paint (FS TT-P-650):
   a. Con-Lux: Jet-Plex 495 Primer.
   b. Devoe: 50801 Wonder-Tones Latex Primer and Sealer.
   c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
   d. S-W: Pro-Mar 200 Latex Wall Primer B28W200.
2. Finish Coat: Flat latex-based paint made for use as a flat finish over prime-coated gypsum board (FS TT-P-29):
   a. Con-Lux: Wall-Plex 400 Series.
   b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
   c. Moore: Regal Wall Satin 215.
   d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

L. Gypsum Board - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
1. Primer: Latex-based white primer made for use on interior gypsum board under an odorless alkyd enamel (FS TT-P-650):
   a. Con-Lux: Jet-Plex 495 Primer.
   b. Devoe: 50801 Wonder-Tones Latex Primer and Sealer.
   c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
   d. S-W: Pro-Mar 200 Latex Wall Primer B28W200.
2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a primer on interior gypsum board under an odorless alkyd enamel:
   a. Con-Lux: Enamel Underbase 54 White.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
   c. Moore: Moore's Alkyd Enamel Underbody 217.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on interior gypsum board (FS TT-E-509):
   a. Con-Lux: Satin-Lite 900 Series.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
   c. Moore: Moore's Satin Impervo Enamel 235.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

M. Woodwork, Stained-Varnish: Two coats over sealer over stain plus filler on open-grain wood. Wipe filler before applying first varnish coat.
1. Stain Coat: Slow-penetrating oil-type wood stain made for general use on interior wood surfaces under a varnish finish (FS TT-S-71):
   a. Devoe: 96XX Wonder Woodstain Alkyd Stain.
   b. Moore: Moore's Interior Wood Finishes Penetrating Stain 241.
   c. S-W: Oil Stain A-48 Series.
2. Sealer: Quick-drying, rosin-free, clear, general-purpose shellac varnish made for use on the interior over stained-finished woodwork under a varnish finish (FS TT-S-300, Grade A):
   a. Devoe: 4900 Wonder Woodsealer Quick-Dry Sealer.
   b. Moore: Moore's Interior Wood Finishes, Quick-Dry Sanding Sealer 413.
   c. S-W: Pro-Mar Varnish Sanding Sealer B26V3.
3. Filler: Solvent-based, air-drying, paste-type wood filler made for use on open-grain wood on interior wood surfaces (FS TT-F-336):
   a. Devoe: 4800 Wonder Woodstain Interior Paste Wood Filler.
   b. Moore: Benwood Paste Wood Filler.
   c. S-W: Sher-Wood Fast-Dry Filler.
4. Undercoat: Clear varnish made for use on interior stained-finished woodwork (FS TT-V-86):
   a. Devoe: 4600 Wonder Wood Satin Alkyd Satin Varnish.

b. Moore: Benwood Satin Finish Varnish 404.
c. S-W: Oil Base Varnish, A66V91/A66F90.

5. Finish Coat: Clear varnish made for use on interior stained-finished woodwork (FS TT-V-86):
a. Devoe: 4600 Wonder Wood Satin Alkyd Satin Varnish.
b. Moore: Benwood Satin Finish Varnish 404.
c. S-W: Oil Base Varnish, A66V91/A66F90.

N. Woodwork, Painted - Alkyd, Semigloss: Two coats over primer.
1. Primer: Enamel undercoat made for use as a primer over wood under an odorless alkyd enamel:
a. Con-Lux: Enamel Underbase 54 White.
b. Devoe: 50501 Interior Alkyd Primer and Vapor Barrier
c. Moore: Moore's Alkyd Enamel Underbody 217.
d. S-W: Wall and Wood Primer B49WZ2.
2. Undercoat: Semigloss odorless alkyd enamel made for use over a primer on wood (FS TT-E-509):
a. Con-Lux: Satin-Lite 900 Series.
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Satin Impervo Enamel 235.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on wood (FS TT-E-509):
a. Con-Lux: Satin-Lite 900 Series.
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Satin Impervo Enamel 235.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

O. Ferrous Metal - Silicone-Alkyd, Semigloss: Two coats over primer:
1. Primer: Lead and chromate-free high solids primer which chemically inhibits rusting and is recommended by the manufacturer for application to steel which has been prepared in accordance with SSPC SP2. Rated 10 (less than 0.01% surface rusting) when tested in accordance with ASTM B117 for 500 hours. Exceeds performance requirements of FS TT-P-636:
a. Con-Lux: Rust Arrestor 50.
b. S-W: Kem Kromik Universal Metal Primer B50NZ6.
c. Tnemec: Series P10.
2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over specified primer for application of silicone-alkyd finish coat:
a. Con-Lux: Ferrox Primer.
b. S-W: Silicone Alkyd Enamel B-56 Series.
c. Tnemec: Series 23 Enduratone.
3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
a. Con-Lux: Steel-Master 9500 Series.
b. S-W: Silicone Alkyd Enamel B-56 Series.
c. Tnemec: Series 82 Silicone-Alkyd Enamel.

P. Ferrous Metal - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
1. Primer: Quick-drying, rust-inhibiting primer made for priming ferrous metal under an odorless alkyd enamel (FS TT-P-664):
a. Con-Lux: Ferrox Primer.
b. Devoe: 41820 Bar-Ox Alkyd Shop/Field Primer.
c. Moore: Ironclad Retardo Rust-Inhibitive Paint 163
d. S-W: Kem Kromik Metal Primer B50N2/B50W1.

2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on ferrous metal under an odorless alkyd enamel:
   a. Con-Lux: Satin-Lite 900 Series.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
   c. Moore: Moore's Alkyd Enamel Underbody 217.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on ferrous metal surfaces (FS TT-E-509):
   a. Con-Lux: Satin-Lite 900 Series.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel
   c. Moore: Moore's Satin Impervo Enamel 235.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

Q. Ferrous Metal - Epoxy, Gloss: Two coats over primer:
1. Primer: Corrosion-inhibitive primer recommended by manufacturer for priming ferrous metal under an epoxy undercoat:
   a. Con-Lux: Epolon Mastic 36 White.
   b. Duron: Dura Clad Universal Phenolic Alkyd Fast Dry Metal Primer.
   c. Moore: IronClad Epoxy Rust Inhibitive Primer
   d. S-W: Recoatable Epoxy Primer.
2. Undercoat: Epoxy undercoat made for use as an undercoat over a primer on metal under a gloss epoxy enamel:
   a. Con-Lux: Epolon Series.
   b. Duron: Dura Clad Polyamide Epoxy.
   c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
   d. S-W: ArmorSeal 100HS Series.
3. Finish Coat:
   a. Gloss epoxy enamel made for use over a primer and epoxy undercoat on metal surfaces.
      1) When the finish coat is applied to a floor surface, add anti-slip aggregate.
   b. Con-Lux: Epolon Series.
   c. Duron: Dura Clad Polyamide Epoxy.
   d. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
   e. S-W: ArmorSeal 100HS Series.

R. Zinc-coated Metal - Alkyd, Semigloss: Two coats over primer, with total dry film thickness not less than 2.5 mils.
1. Primer: Galvanized metal primer made for use on zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following:
   a. Con-Lux: Bond-Plex 46 Barrier Green.
   b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
   c. Moore: Ironclad Galvanized Metal Latex Primer 155.
   d. S-W: Industrial Water Based Acrylic Paint B42W110.
2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on zinc-coated metal under an odorless alkyd enamel:
   a. Con-Lux: Satin-Lite 900 Series.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
   c. Moore: Moore's Alkyd Enamel Underbody 217.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on zinc-coated (galvanized) metal surfaces (FS TT-E-509):
   a. Con-Lux: Satin-Lite 900 Series.
   b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
   c. Moore: Moore's Satin Impervo Enamel 235.
   d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

S. Zinc-Coated Metal - Silicone-Alkyd, Semigloss: Two coats over factory-applied primer:
1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following.
   a. Con-Lux: Bond-Plex 46 Barrier Green.
   b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
   c. Moore: Ironclad Galvanized Metal Latex Primer #155.
   d. S-W: Industrial Water Based Acrylic Paint B42W110.
2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over factory-applied primer for application of silicone-alkyd finish coat:
   a. Con-Lux: Ferrox Primer.
   b. S-W: Silicone Alkyd Enamel B-56 Series.
   c. Tnemec: Series 23 Enduratone.
3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
   a. Con-Lux: Steel-Master 9500 Series.
   b. S-W: Silicone Alkyd Enamel B-56 Series.
   c. Tnemec: Series 82 Silicone-Alkyd Enamel.

T. Zinc-Coated Metal - Epoxy, Gloss: Two coats over primer:
1. Primer: Primer recommended by manufacturer for priming galvanized metal under an epoxy undercoat:
   a. Con-Lux: Metal Bond 47 Primer.
   b. Duron:
      1) Vinyl Wash Primer for surfaces subject to abrasion;
      2) Dura Clad Acrylic Galvanized Metal Primer for surfaces not subject to abrasion.
   c. Moore: IronClad Galvanized Metal latex Primer.
   d. S-W: ArmorSeal 100HS Series.
2. Undercoat: Epoxy undercoat made for use as an undercoat over a primer on metal under a gloss epoxy enamel:
   a. Con-Lux: Epolon Series.
   b. Duron: Dura Clad Polyamide Epoxy.
   c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
   d. S-W: ArmorSeal 100HS Series.
3. Finish Coat;
   a. Gloss epoxy enamel made for use over a primer and epoxy undercoat on metal surfaces.
      1) When the finish coat is applied to a floor surface, add anti-slip aggregate.
   b. Con-Lux: Epolon Series.
   c. Duron: Dura Clad Polyamide Epoxy.
   d. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
   e. S-W: ArmorSeal 100HS Series.

U. Non-Ferrous Metal - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
1. Primer: Corrosion inhibitive primer recommended by manufacturer for priming non-ferrous metal under an odorless alkyd enamel:
   a. Con-Lux: Bond-Plex 46 Barrier Green.
   b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
   c. Moore: Ironclad Retardo Rust-Inhibitive Paint 163.
   d. S-W: Kem Kromik Metal Primer B50N2/B50W1.
2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on non-ferrous metal under an odorless alkyd enamel:

a. Con-Lux: Satin-Lite 900 Series.
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Alkyd Enamel Underbody 217.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on non-ferrous metal surfaces (FS TT-E-509):
a. Con-Lux: Satin-Lite 900 Series.
b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
c. Moore: Moore's Satin Impervo Enamel 235.
d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100

V. Cotton or Canvas Covering over Insulation - Latex, Flat: 2 coats.

1. Undercoat: Flat latex-based paint with fungicidal agent added (to render fabric mildew-proof) made for use as a sealing coat (size) on cotton or canvas covering over insulation:
a. Con-Lux: Wall-Plex 400 Series.
b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
c. Moore: Regal Wall Satin 215.
d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

2. Finish Coat: Flat latex-based paint with fungicidal agent added (to render fabric mildew-proof) made for use as a sealing coat (size) on cotton or canvas covering over insulation:
a. Con-Lux: Wall-Plex 400 Series.
b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
c. Moore: Regal Wall Satin 215.
d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

PART 3 - EXECUTION

3.01 PREPARATORY WORK:

A. Inspect surfaces for their suitability to receive a finish. In the event that imperfections due to materials or workmanship appear on surfaces, make the appropriate corrections at no additional cost to the Authority. Correct damage to painted or decorated finishes due to carelessness or negligence of other trades.

B. Protect hardware, hardware accessories, plates, lighting fixtures and similar items installed prior to painting; remove protection upon completion of each space. Where necessary to remove installed products to ensure their protection, arrange for removal and reinstallation by mechanics of the trade involved. Disconnect equipment adjacent to walls; where necessary, move to permit painting of wall surfaces, and following completion of painting, replace and reconnect.

C. Clean surfaces to be painted as necessary to remove dust and dirt. Sand as necessary to properly prepare surfaces to receive paint or varnish.

D. Wash metal surfaces with benzine or mineral spirits to remove dirt, oil or grease before applying paint. Where rust or scale is present, wire brush or sandpaper clean before painting. Apply galvanized metal primer to degreased galvanized metal before applying additional coats.

E. Prepare masonry surfaces to be painted by removing dirt, dust, oil and grease stains and efflorescence. The method of surface preparation is at the discretion of the Contractor provided that the results are approved. Clean masonry and plaster surfaces to be painted

until they are free from alkali and thoroughly dry before applying paint. Test masonry and plaster surfaces for alkali, using red litmus paper, prior to painting.

F. Clean concrete surfaces free from dirt, or film left from form oil or concrete curing compounds, or loose or excess mortar. Steam clean or wash the surfaces with water. Use cleaning additive with discretion, in accordance with paint manufacturer's recommendation and to the satisfaction of Engineer.

G. Cut out cracks, scratches and other imperfections in plaster surfaces as required, fill with spackling compound and sand flush with adjacent surface. Fill voids in concrete with cement grout before painting.

H. Fill nail holes and cracks after first coat with non-shrinking putty of a color to match that of the finish.

I. Sand, dust and touch up scratches, abrasions or other disfigurements and remove foreign matter from prime coats before proceeding with the following coat. Featheredge spotpriming or spot coating into adjacent coatings to produce a smooth and level surface.

J. Test concrete and plaster surfaces for moisture, using moisture meter, prior to painting. Do not apply paint to surfaces having meter reading above 15.

K. Caulk joints between door and window frames and walls, and other joints as necessary.

L. Coordinate the work of this section with the work of other trades.

3.02 APPLICATION:

A. Touch-up painting of structural steel, miscellaneous metal, hollow-metal doors and frames, and other materials which have been prime coated as may be required where the shop coat has been damaged by welding or abrasion during the handling and erection operations; also rivets, bolts and welds which are unpainted after assembly and erection.

B. Apply paint by spray in accordance with the manufacturer's directions to achieve required dry film thickness (DFT). Where specifically approved by the Engineer, use rollers or brushes as best suited for material being applied. For covers on rollers use carpet with velvet back and high-pile sheep's wool or use short-hair covers, as best suited for material and texture specified. Except where otherwise noted, apply paint to a minimum dry-film thickness (DFT) of five mils, excluding filler coats, using no less than the number of coats specified in Part 2 – Products.

C. Apply material evenly and smoothly without runs, sags or other defects with edges of paint adjoining other materials or color sharp and clean, without overlapping.

D. Do not paint and finish while surfaces are damp. Allow sufficient time between coats, in accordance with manufacturer's directions to produce an evenly smooth finish.

E. Do not apply final coats until after other trades, whose operations would be detrimental to finish painting, have finished their work in the areas to be painted and the areas have been approved for painting.

3.03 PROTECTION:

A. Dispose of soiled cleaning rags and waste at the close of each day's work or store such soiled rags and waste in metal containers with tight-fitting covers. Provide buckets of sand

during painting operations for use in the event of fire. Post NO SMOKING signs as necessary and as directed.

B. Protect the work of other trades against damage or injury by use of suitable covering during the progress of the painting and finishing work. Repair damage to the satisfaction of the Engineer.

3.04 CLEANING:

A. Upon completion of work, remove staging, scaffolding and containers from the site. Remove paint spots, oil or stains from glass, floors and other surfaces not to be painted, and leave job clean and acceptable to the Engineer.

3.05 COLOR CODING OF PIPING AND EQUIPMENT:

A. General Requirements:
1. Color coding is required for accessible piping systems and related equipment, except associated supports, brackets, hangers and similar accessories.
2. Identify piping systems and related equipment which are to be color coded as follows:
   a. Apply color to entire length of piping.
   b. Apply lettered legends indicating the name of the contents of the system as specified.

B. Location of Legends and Bands:
1. Stencil lettered legends on the piping at the horizontal or vertical centerline. Where pipe lines are too close together and where located above the operator's normal line of vision, place the lettering below the horizontal centerline at a point which will be easily visible.
2. Locate lettered legends and bands at points where pipes enter and leave rooms or spaces, at junction points and points of distribution, close to valves and equipment, at changes in direction, and at intervals along piping where necessary for identification.
3. Stencil piping in accordance with ASME A13.1 and as follows to show service and direction of flow, space within sight of each other and not more than 40 feet apart on long runs.

C. Size of Stencil Letters for Piping Identification:

Outside Diameter of Pipe Covering in Inches	Size of Letter in Inches	Width of Color Band in Inches
3/4 to 1-1/4	1/2	4
1-1/2 to 2-1/2	3/4	6
3 to 6	1-1/4	8
7 to 10	2-1/2	12
Over 10	3-1/2	12

D. Schedule of Colors and Legends:

Line	Pipe Color	Black Stenciled Legend
Hot water lines	Yellow	HW, HWR
Potable cold water lines	Blue	CW
Chilled water lines	Blue with yellow band	CHWS, CHWR
Fire lines	Red	F (use White Stencil instead of black)
Condensate lines	White	C
Condenser water lines	White with blue band	CWS, CWR
Soil and waste lines	White	S
Vent lines	Grey with white band	V
Storm Water lines	White	ST-W
Air and control air lines	Green	A

END OF SECTION

SECTION 10200

METAL LOUVERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing fixed, extruded aluminum and formed-metal louvers, blank-off panels and accessories.

B. Related Work Specified Elsewhere:
   1. Seals and Sealants: Section 07900.
   2. Metal Doors and Frames: Section 08110.
   3. Field Painting: Section 09920.

1.02 DEFINITIONS:

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section, unless otherwise defined in this Section or in referenced standards.

B. Standard Free Area: Free area of a louver 48 inches wide by 48 inches high, identical to that provided.

C. Maximum Standard Airflow: Airflow at point of beginning water penetration through a louver 48 inches wide by 48 inches high, identical to that provided.

D. Drainable-Blade Louver: Louver designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and channels in jambs and mullions.

1.03 PERFORMANCE REQUIREMENTS:

A. Structural Performance: Provide exterior metal louvers capable of withstanding the effects of loads and stresses from wind and normal thermal movement without evidencing permanent deformation of louver components including blades, frames, and supports; noise or metal fatigue caused by louver blade rattle or flutter; or permanent damage to fasteners and anchors.
   1. Wind Load: Uniform pressure (velocity pressure) of 20 lbf/sq. ft., acting inward or outward.
   2. Thermal Movements: Provide louvers that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, and other detrimental effects:
      a. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

B. Air-Performance, Water-Penetration, and Air-Leakage Ratings: Provide louvers complying with performance requirements indicated, as demonstrated by testing manufacturer's stock units 48 inches wide by 48 inches high. Test units according to AMCA 500.
   1. Perform testing on unpainted, cleaned, degreased units.
   2. Perform water-penetration testing on louvers without screens.

1.04 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Product Data: For each type of product specified provide manufacturer's printed product information.
2. Shop Drawings: For louver units and accessories. Include plans; elevations; sections; and details showing profiles, angles, and spacing of louver blades. Show unit dimensions related to wall openings and construction; free area for each size indicated; profiles of frames at jambs, heads, and sills; and anchorage details and locations.
   a. For installed louvers and vents indicated to comply with design loadings, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.
4. Samples for Verification: Of each type of metal finish required, prepared on Samples of same thickness and material indicated for final Work. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.
5. Product Certificates: Signed by manufacturers of louvers certifying that the products furnished comply with requirements and are licensed to bear the AMCA seal based on tests made according to AMCA 500 and complying with AMCA's Certified Ratings Program.

1.05 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Codes and regulations of the jurisdictional authorities.
2. AAMA: 603.8, 605.2, 607.1.
3. AMCA: 500, 501.
4. ASTM: A653, a780, B26, B209, B221, C612, D1187.
5. AWS: D1.2, D1.3.
6. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
7. SMACNA: Architectural Sheet Metal Manual.
8. SSPC: Paint 12.Codes, Regulations, Reference Standards and Specifications:
9. Codes and regulations of the jurisdictional authorities.
10. ASTM:
11. AWS: D1.2., D1.3.
12. NAAMM: Metal Finishes Manual for Architectural and Metal Products.SMACNA: Architectural Sheet Metal Manual.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of kind indicated. Engineering services are defined as those performed for installations of louvers that are similar to those indicated for this Project in material, design, and extent.

C. Source Limitations: Obtain louvers and vents through one source from a single manufacturer where alike in one or more respects regarding type, design, or factory-applied color finish.

D. Welding Standards: As follows:
1. Comply with AWS D1.2, "Structural Welding Code--Aluminum."
2. Comply with AWS D1.3, "Structural Welding Code–Sheet Steel."Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone re-certification.

E. SMACNA Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

1.06 PROJECT CONDITIONS:

A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
   1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.

PART 2 -PRODUCTS

2.01 MATERIALS:

A. Aluminum Extrusions: ASTM B221, alloy 6063-T5 or T-52

B. Aluminum Sheet: ASTM B209, alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish

C. Aluminum Castings: ASTM B26/B26M, alloy 319.

D. Galvanized Sheet Steel: ASTM A653/A653M, G90 zinc coating, mill phosphatized.

E. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
   1. Use types and sizes to suit unit installation conditions.
   2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.

F. Anchors and Inserts: Of type, size, and material required for loading and installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as needed for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.

G. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12 but containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.02 FABRICATION, GENERAL:

A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
   1. Continuous Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates and without interrupting blade-spacing pattern.

B. Maintain equal louver blade spacing to produce uniform appearance.

C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining materials' tolerances, and perimeter sealant joints.

D. Include supports, anchorages, and accessories required for complete assembly.Provide vertical mullions of type and at spacings indicated, but not more than recommended by

manufacturer, or 72 inches o.c., whichever is less. At horizontal joints between louver units, provide horizontal mullions, unless continuous vertical assemblies are indicated.

E. Provide sill extensions and loose sills made of same material as louvers where indicated or required for drainage to exterior and to prevent water penetrating to interior.

F. Join frame members to one another and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer, concealed from view; unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.03 FIXED, EXTRUDED-ALUMINUM LOUVERS:

A. Louver Construction: Provide fixed-blade louvers with extruded-aluminum frames and blades.

B. Horizontal Louvers: Either drainable- or nondrainable-blade (as indicated) type complying with the following:
1. Louver Depth: As indicated.
2. Frame Thickness: 0.125 inch, or as indicated.
3. Blade Thickness: 0.125 inch, or as indicated.
4. Performance Requirements: As indicated.
5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

C. Continuous, Horizontal, Drainable-Blade Louvers: Fabricated with close-fitting, field-made splice joints in blades designed to permit expansion and contraction without deforming blades or framework and with mullions recessed from front edges of blades so blades have continuous appearance.
1. Louver Depth: As indicated.
2. Frame Thickness: 0.125 inch, or as indicated.
3. Blade Thickness: 0.125 inch, or as indicated.
4. Blade Profile: As indicated.
5. Blade Angle and Spacing: As indicated.

2.04 FIXED, FORMED-METAL LOUVERS:

A. Louver Construction: Provide fixed-blade louvers with frames and blades formed from metal sheet of metal indicated.

B. Horizontal Louvers: Either drainable- or nondrainable-blade type (as indicated) complying with the following
1. Louver Depth: As indicated.
2. Frame and Blade Material: Galvanized steel sheet, 0.052 inch.
3. Performance Requirements: As indicated.

2.05 LOUVER SCREENS:

A. General: Provide each exterior louver with louver screens complying with the following requirements:
1. Screen Location for Fixed Louvers: Interior face.
2. Screening Type: Bird screening, unless otherwise indicated.
3. Screening Type: Insect screening, as indicated.

B. Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate screen frames with mitered corners to louver sizes indicated and to comply with the following requirements:
   1. Metal: Same kind and form of metal as indicated for louver to which screens are attached..
      a. Reinforce extruded-aluminum screen frames at corners with clips.
   2. Finish: Same finish as louver frames to which louver screens are attached.
   3. Type: Rewirable frames with a driven spline or insert for securing screen mesh.

D. Louver Screening for Aluminum Louvers: As follows:
   1. Bird Screening: Aluminum, ½-inch-square mesh, 0.063-inch wire
   2. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

E. Louver Screening for Galvanized Steel Louvers: As follows:
   1. Bird Screening: Galvanized steel, ½-inch square mesh, 0.047-inch wire.
   2. Insect Screening: Galvanized steel, 18-by-14 mesh, 0.011-inch wire.
   3. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

F. Louver Screening for Galvanized Steel Louvers: As follows:
   1. Bird Screening: Galvanized steel, 1/2-inch-square mesh, 0.047-inch wire.
   2. Insect Screening: Galvanized steel, 18-by-14 mesh, 0.011-inch wire.

2.06 BLANK-OFF PANELS:

A. General: Fabricate blank-off panels from materials and to sizes indicated and comply with the following requirements:
   1. Finish: Same as finish applied to louvers.
   2. Attach blank-off panels to back of louver frames with clips.

B. Insulated, Blank-off Panels: Laminated metal-faced panels consisting of insulating core surfaced on back and front with metal sheets, complying with the following requirements:
   1. Thickness: 1 inch.
   2. Metal Facing Sheets: Aluminum sheet, 0.032 inch thick.
   3. Insulating Core: Unfaced, rigid, glass-fiberboard insulation complying with ASTM C612, Class 1 and 2.
   4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames 0.081 inch -thick, with corners mitered and with same finish as panels.

2.07 FINISHES, GENERAL:

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish louvers after assembly.

2.08 ALUMINUM FINISHES:

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.

B. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 607.1.

C. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.
   1. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 603.8, except with a minimum dry film thickness of 1.5 mils, medium gloss.
   2. Color: As selected by the Engineer from manufacturer's full range of colors.

D. High-Performance Organic Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.
      a. Color and Gloss: As selected by the Engineer from manufacturer's full range of colors and glosses.

2.09 GALVANIZED STEEL SHEET FINISHES:

A. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A780. Apply a conversion coating of type suited to organic coating applied over it.

B. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with not less than 1.0-mil dry film thickness for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2.0 mils.
   1. Color and Gloss: As selected by the Engineer from manufacturer's full range of colors and glosses.

PART 2 - EXECUTION

3.01 PREPARATION:

A. Coordinate Setting Drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.02 INSTALLATION:

A. Locate and place louver units level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated

E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

G. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses, where weathertight louver joints are required. Comply with Section 07900 for sealants applied during louver installation.

3.03 ADJUSTING, CLEANING, AND PROTECTING:

A. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.

B. Periodically clean exposed surfaces of louvers and vents that are not protected by temporary covering to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

D. Protect louvers and vents from damage during construction. Use temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at the time of Substantial Completion.

E. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
   1. Clean and touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION

SECTION 11010

ROOF ANCHORS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Work of this section includes the design, supply and installation of anchors for window washing/suspended maintenance equipment.

B. Related work specified elsewhere:
1. Division 3 - Concrete
2. Division 5 - Metals
3. Division 7 - Thermal And Moisture Protection

1.02 REFERENCES:

A. AISC publication "Load and Resistance Factor Design Specification for Structural Steel Buildings".

B. AISI publication "Specification for Design of Cold-Formed Steel Structural Members (1986 & 1989 Addendum).

C. Aluminum Association publication No.30 "Specification for Aluminum Structures" and AWS D1.2-90 Structural Welding Code - Aluminum.

D. AWS D1.1 Structural Welding Code - Steel.

1.03 DESIGN REQUIREMENTS:

A. Design window washing/suspended maintenance system to suit building and in accordance with plans, specifications, standards, and regulations/codes contained in section 1.4 and 1.8.

B. Locate safety and tie-back anchors to suit suspension equipment which will be used on the building with respect to items such as reach, rigging,spacing, roof edge condition and similar items.

C. Design all anchor components to provide adequate attachment to the building and suited to current window washing/suspended maintenance practices. Ensure compatibility with industry standard equipment.

D. Ensure all anchor components conform to proper engineering principles and have been designed by a Professional Engineer qualified in the design of window washing/suspended maintenance equipment, its application and safety requirements.

E. Design system fall arrest safety anchors to comply with the following structural requirements:

1. Designed to resist a 5,000 lb. (22.2 kN) horizontal load in any direction without detachment or fracture occurring. This load is considered to be an ultimate peak dynamic load and yielding of the anchor and structure in the event of a fall is not precluded. To avoid deformation under normal usage, anchors are to be generally designed to resist a 1,000 lb. (4.5 kN) static horizontal load in any direction without yielding.

1.04 SHOP DRAWINGS AND ENGINEERING CERTIFICATION

A. Submit shop drawings showing complete layout and configuration of complete window washing/suspended maintenance system, including all components and accessories. Clearly indicate design and fabrication details, window "drops", hardware, and installation details.

B. Shop drawings to include installation and rigging instructions and all necessary Restrictive and Non- Restrictive Working Usage Notes and General Safety Notes.

C. Shop drawings complete with calculations to be reviewed by and bearstamp of a professional engineer.

1.05 QUALIFICATIONS

A. Manufacturer: Work of this Section to be executed by manufacturer specializing in the design, fabrication and installation of window washing/suspended maintenance systems having a minimum of 5 years documented experience

B. Loading and safety assurance: Work of thisSection to meet the requirements of governing codes and jurisdiction and to comply with properly engineered loading and safety criteria for the intended use.

C. Insurance: Manufacturer to carry specific liability insurance (products and completed operations) in the amount of $2,000,000.00 to protect against product/system failure.

D. Welding to be executed by welders qualified to work in the State in which the project is being completed.

1.06 REGULATORY REQUIREMENTS

A. Comply with the following OSHA regulations:
1. 1910, Subpart D (Walking and Working Surfaces).
2. Appendix C to 1910 (Personal Fall Arrest Systems).
3. "OSHA Ruling on Window Cleaning by Bosun's Chair" Memorandum toRegional Administrators from P. K. Clark, Director, Directorate of Compliance Program
4. 1910, Subpart F (Powered Platforms).

1.07 MAINTENANCE DATA

A. Submit 1 copy of system Equipment Manual & Inspection Log Book, with "Initial Inspection - Certification for Use" and "Inspection Sign-Off" forms completed.

B. Submit 2 copies of a reduced plastic laminated as-built shop drawing showing equipment locations and details. This drawing is to be posted near exits onto the roof.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. This specification is generally based on systems currently being manufactured by PRO-BEL, Telephone: (905) 427-0616, Fax: 905-427-2545, Toll free: 1-800-461-0575.

B. Other manufactured products meeting this specification may be substituted provided that manufacturers show proof of product insurance.Equipment details to be approved by The

Engineer.Companies, such as miscellaneous metal fabricators, who are not normally engaged in the design and manufacture of window washing/suspended maintenance equipment are not permitted to bid.

2.02 EQUIPMENT

A. Through bolted roof anchors as manufactured by, but not limited to:
   1. PRO-BEL Model EPB-73S

2.03 MATERIALS

A. U-bar, anchor bolts Type 304 stainless steel with yield strength of 42 Ksi (290 MPa). U-bar to be not less than 3/4" (19 mm) diameter material with 1-1/2" (38 mm) eye opening.

B. Hollow steel section (HSS) piers: galvanized steel as above with yield strength of 50 Ksi (345 MPa), [with] [without] urethane foam insulation.Wall thickness to suit application.

C. Base plate and all other sections: galvanized mild steel as above with yield strength of 43 Ksi (297 MPa). Thickness and securement to suit application.

D. Seamless spun aluminum flashing (for steel pier anchors): Type 6061-T6 alloy to ASTM B221 with deck flange flashed in to NRCA recommendations.Seal top of aluminum flashing with conformable mastic tape and torch applied heat-shrink rubber membrane.

E. Bolts, nuts and washers: ASTM A36, galvanized to ASTM A123.

2.04 FABRICATION

A. General:
   1. Fabricate work true to dimension, square, plumb, level and free from distortion or defects detrimental to appearance and performance.
   2. Grind off surplus welding material and ensure exposed internal corners have smooth lines.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces and areas upon which the work of this Section depends. Report to the Contractor in writing, defects of work prepared by other trades and other unsatisfactory site conditions which would cause defective installation of products, or cause latent defects in workmanship and function.

B. Verify site dimensions.

C. Commencement of work will imply acceptance of prepared work.

3.02 INSTALLATION

A. Install equipment in accordance with approved shop drawings and manufacturer's recommendations.

B. Co-ordinate installation with work of related trades.

C. Install all work true, level, tightly fitted and flush with adjacent surfaces as required.

D. Deform threads of tail end of anchor studs after nuts have been tightened to prevent accidental removal or vandalism.

E. Manufacturer to assist and/or supervise installation of window washing/suspended maintenance equipment installed by others.

F. Structural steel to receive rooftop anchors equipped with 4" (100 mm) diameter HSS pier to have minimum 5" (127 mm) wide bearing surface to ensure 100% weld.

3.03 FINAL ADJUSTING AND INSPECTION

A. Adjust and leave equipment in proper working order.

B. Complete "Initial Inspection - Certification for Use" form included in Equipment Manual & Inspection Log Book.

3.04 TESTING

A. All anchorage systems relying upon chemical adhesive fasteners to be 100% tested on site using load cell test apparatus in accordance with manufacturer's recommendations.

B. Load cell test to apply minimum 5,000 lb. (22.2 kN) load without detachment or fracture occurring.

END OF SECTION

SECTION 13110

STRAY CURRENT AND CATHODIC PROTECTION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing and connecting stray-current and cathodic-protection equipment.

B. Related Work Specified Elsewhere:
1. Grading, excavation and backfilling: Section 02320.
2. Corrosion control system testing: Section 13115.
3. Grounding and bonding: Section 16060.
4. Wire, cable and busways: Section 16120.
5. Wire connection accessories: Section 16125.
6. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of jurisdictional authorities.
2. ICEA: S-61-402.
3. ASTM: B418, D256, D570, D638, D693, D1248, E11.
4. MS: MIL-A-18001.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings.

2. Certification:
a. Certified test reports of field quality-control testing.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each item with manufacturer's name, brand designation, referenced standard, type, class and rating, as applicable.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store equipment in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Cast-Iron Anodes:
1. Size and type: As shown.
2. Chemical composition:

Element	Percent
Silicon	14.33
Chromium	4.5
Carbon	0.85
Manganese	0.65
Iron	Remainder

3. Physical properties:
   a. Tensile strength: 15,000 psi.
   b. Compressive strength: 100,000 psi.
   c. Brinell hardness: 520.
   d. Density: 7.0 grams per cubic centimeter.
   e. Melting point: 2,300F.
   f. Specific resistance: 72 microhms per centimeter cube at 20C.
   g. Coefficient of expansion: 7.33 x 10^{-6} per degree F from 32F to 212F.
4. Lead wire: Single-conductor insulated cable, 8AWG minimum, factory-connected to anode with connection sealed with cast epoxy-resin encapsulation.
5. Anode packaged as follows:
   a. Stove pipe: Galvanized steel, 30-gauge minimum, in accordance with the one of the following:
      1) Diameter: Eight inches; Length: Eight feet.
      2) Diameter: Five inches; Length: Six feet.
   b. Ends of pipe crimped to end seal of ½-inch interior-grade plywood.
   c. Containing compacted backfill of coke breeze of graded coal or recalcined petroleum coke, with the following additional requirements:
      1) Resistivity on dry basis: 60 ohms per centimeter cube, maximum.
      2) Chemical composition:

Material	Percent
Fixed carbon	78.22 - 78.40
Ash	18.6 maximum
Moisture	9.50 - 14.70
Volatile matter	3.00 - 3.14
Sulphur	1.2 maximum

      3) Gradation:
         a) Sieve size in accordance with ASTM E11.
         b) Requirements:

Percent Passing	Sieve Size
½ inch	100
3/8 inch	85
No. 6	65

B. Magnesium Anodes:

1. Packaged anodes, type and size as shown.
2. Chemical composition for high-potential type anodes:

Element	Percent
Aluminum	0.010 maximum
Manganese	0.50 - 1.30
Zinc	0.050 maximum
Silicon	0.050 maximum
Copper	0.020 maximum
Nickel	0.001 maximum
Iron	0.030 maximum

Element (Cont.)	Percent (Cont.)
Other metallic elements	0.050 each or 0.300 maximum total
Magnesium	Remainder

3. Lead wire: Single-conductor insulated cable, 12AWG minimum, factory-connected to anode with connection sealed with cast epoxy-resin encapsulation.
4. Anode packaged in permeable cloth sack containing compacted backfill of mixture with the following requirements:

Material	Percent
Gypsum	75
Bentonite	20
Sodium sulphate	5

C. Zinc Anodes: MS MIL-A-18001, bare-ribbon 5/8 by 7/8-inch section or packaged anode, type and size as shown, with the following additional requirements:
1. Lead wire: Single-conductor insulated cable, 12AWG minimum, factory-connected to the anode with connection sealed with cast epoxy-resin encapsulation.
2. Anode packaged in permeable cloth sack containing compacted backfill of mixture consisting of 50-percent hydrated gypsum and 50-percent bentonite.

D. Reference Electrode: ASTM B418, Type II, one galvanized-steel rod, factory-connected to electrode and equipped with two bolted connectors suitable for 12AWG single-conductor insulated cable.

E. Test Boxes:
1. Cathodic-protection test boxes: Plastic, each five inches inside diameter by 18 inches long, with cast-iron lid, collar and terminal board.
2. Stray-current test boxes: Six inches cubical, galvanized cast-iron box with watertight cover.

F. Wire and Cable:
1. Header cable, bond wire and cast-iron anode lead wire in accordance with the following:
   a. Single-conductor.
   b. Size: As shown.
   c. Insulation: HMWPE, 600 volt, in accordance with the following:
      1) ASTM D1248, Type I, Class C, Grade 5.
      2) ICEA S-61-402.
2. Magnesium or zinc anode lead and test wire:
   a. Single-conductor.
   b. Size: 12AWG unless otherwise shown.
   c. Color: As shown; anode lead as furnished.
   d. Insulation: TW, 600-volt, moisture-resistant thermoplastic in accordance with UL 83.

G. Pipeline-Casing Spacers:
1. Virgin polyethylene, molded.
2. Runner height: Sufficient to provide ½-inch clearance between pipe, couplings and hubs as well as internal casing wall.
3. Color: Natural.
4. In accordance with the following:

Characteristic	Reference	Requirement
Compressive strength	ASTM D693	3,200 psi
Tensile strength	ASTM D638,	3,100 - 5,500 psi
Impact strength	ASTM D256	1.5 - 2.0 foot-pound per inch notch
Water absorption	ASTM D570	0.1 percent
Temperature	-	180F (80C) maximum

5. Bolts:
   a. Steel, cadmium-plated.
   b. Sizes: As standard with the manufacturer.
6. Nuts:
   a. Steel, cadmium-plated, square.
   b. Sizes: To match bolts.

H. Pipeline-Casing End Seals:
1. Type L:
   a. Modular mechanical-type.
   b. Consisting of interlocking synthetic-rubber links with cadmium-plated steel nuts and bolts.
   c. Depth limitations: As shown.
2. Type H:
   a. Compression-ring seals.
   b. Nonconductive sleeve: Fiberglass reinforced epoxy (FRE), Adyl Type D or equal, with cadmium-plated steel nuts and bolts.

c. Depth limitations: As shown.

I. Insulating Gasket:
1. Asbestos, all-temperature.
2. Full-face.
3. Thickness: 1/8 inch.
4. Johns-Mansville 71 or equal.

J. Insulating Sleeves and Washers:
1. Up to 300F:
a. Sleeve: Mylar tube, 1/32-inch thick.
b. Washer: Phenolic, 1/8-inch thick.
2. 300F and above:
a. Sleeve: Klingerit or equal, 1/32-inch thick.
b. Washer: Johns-Mansville 71 or equal, Teflon.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Bury anodes or electrodes of type and at location shown. Excavate and backfill holes in accordance with Section 02320, with the following additional requirements:
1. Wet packaged anode thoroughly before backfilling hole.
2. Use fine clay soil, free from stones and bricks, for backfilling.

B. Install header cable of size and at location shown, in accordance with Section 16120.

C. Install test boxes of type and at location shown.

D. Connect anode lead wires to header cable or test boxes as shown.

E. Isolate pipes of different metals and Authority pipes from utility-company pipes using insulated union, compression insulating couplings, or insulated flange and bolt connections. Connect each side of insulated joints to test box using conductors as shown.

F. Where Authority pipes cross utility-company pipes, connect Authority pipes to test boxes using two 12AWG and one 4AWG conductors as shown.

G. Bond joints in buried metallic pipe and structure in accordance with Section 16060. Connect buried metallic pipe and structure to test boxes using single-conductor insulated cable of size shown.

H. Install conduit of type shown, in accordance with Section 16130.

I. Install single-conductor insulated cable in accordance with Section 16120. Leave one foot of slack in test boxes.

J. Use thermit weld sealed with cast epoxy-resin encapsulation for splices made in direct-burial cable.

K. Use compression-type connectors in accordance with Section 16125.

L. Install casing spacers in accordance with manufacturer's recommendation, except maximum spacer distance not to exceed 10 feet.

3.02 IDENTIFICATION:

A. Identify wire and cable in each test box using nonmetallic fiberboard or plastic tags or pressure-sensitive labels.

3.03 FIELD QUALITY CONTROL:

A. Provide necessary equipment and perform testing in the presence of the Engineer in accordance with Section 13115.

END OF SECTION

SECTION 13115

CORROSION CONTROL SYSTEM TESTING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies test procedures for corrosion-control systems.

B. Related Work Specified Elsewhere:
   1. Wire, cable and busways: Section 16120.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of jurisdictional authorities.

B. Instrument Calibration:
   1. Calibrate test instruments within six months prior to use on this project.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Working Drawings:
      a. Layout of system being tested, showing location of system components, including test stations.
      b. Instrument hook-up for each test.
   2. Certification:
      a. Certified test report for each test conducted including the following:
         1) Types, models, serial numbers, and dates of calibration of all instruments.
         2) Data resulting from specified test procedures, in approved format.
      b. Certificates of inspection.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Wire and Cable: Section 16120.

PART 3 - EXECUTION

3.01 TEST EQUIPMENT:

A. DC Voltmeter: Multi-scale, center zero, minimum sensitivity 50,000 ohm/volt, accurate to within one percent of full scale, covering the following full-scale ranges: 0-10 and 0-100 millivolts; 0-1, 0-10, 0-100 volts.

B. DC Ammeter: Multi-scale, maximum shunt drop of 20-mV sensitivity, or millivolt meter and shunts, accurate to within one percent of full scale, covering the following full-scale ranges: 0-1, 0-10, 0-100 amperes.

C. Resistivity Meter: Self-contained, synchronous-vibrator, battery-powered unit. Instrument readings unaffected by resistance of leads or probes.

D. DC-Power Sources: Automotive wet-cell batteries, six or 12 volts. For circuits with high internal resistance use two or more batteries, a dc generator or cathodic-protection rectifier.

E. Test Cable: Single-conductor cable, stranded copper, assorted sizes and lengths to suit test conditions.

F. Steel probes for making electrical contact to buried structures in absence of test stations.

G. Slide-Wire Resistors: 0-400 ohm, 15-ampere capacity over full-range of adjustment.

H. Reference Half-Cell: 7/8-inch diameter by eight inches long, saturated copper-copper sulfate.

3.02 TEST PROCEDURES:

A. Electrical Continuity:

1. Test the following items for continuity:
   a. Mechanical and bell-and-spigot pipe joints: Test after backfilling is completed. Test individual and multiple bonds.
   b. Metallic tunnel-liner joints: Test after invert has been cast. Test longitudinal bonds individually or in sections not to exceed 150-linear feet.
   c. Concrete reinforcement in tunnel, station, retaining wall, reinforced-concrete pipe, aerial, floating slab and building structures: Test after concrete has been cast. Test bonded joints individually or in sections not to exceed 150 feet for tunnel and station structures, not to exceed 500-linear feet for other structures.
   d. Underpinning, soldier and structural piles: Test prior to backfilling or use leads in structure after backfilling. Test bonded piles individually or in longitudinal sections not exceeding 600-linear feet.
2. Test Procedure:
   a. Single bond: Connect instruments across bond to be tested as shown. Use separate set of wires and contact points to structures for voltage and current circuits. Beginning with highest scales on voltmeter and ammeter, close switch and observe meter readings. Reduce meter ranges until lowest possible scale is reached. Adjust current level to less than five amperes. Read ON values of voltage and current, break circuit and immediately read OFF values. Record ON and OFF readings on data sheet and determine incremental change for current and voltage. Obtain minimum of three readings to ensure accuracy. Determine and record bond resistance for each reading. Resistance of bond not to exceed calculated theoretical resistance by more than 10 percent.
   b. Multiple bonds in parallel: Where two structures are bonded by multiple bonds in parallel, test as specified for single bond. Record resistance readings obtained. Actual resistance not to exceed 10 percent of calculated theoretical resistance of bonds.
   c. Multiple bonds in series: Connect instruments as shown. Determine and record resistance between points A and B, including bonds in series as specified for single-bond test. Total resistance measured between points A and B not to exceed 10 percent of theoretical resistance of sum of bonds plus theoretical resistance of structure between points A and B.

d. Multiple bonds in parallel on reinforcing steel: Connect instruments as shown. Determine and record resistance between points A and B, including bonds in parallel as specified for single-bond test.

B. Insulating Joints:
1. Test the following for zero-percentage leakage through insulation.
a. Insulated flanges and unions: Test buried flanges and fittings after backfilling is completed. Test exposed flanges and fittings after installation is completed. Test each flange or union individually, using existing test wires.
b. Casing and sleeve insulation: Test prior to backfilling. Test each casing or sleeve individually.
2. Test Procedures:
a. Set up instrumentation as shown. If pipe length is too short for proper test-connection spacing, use maximum possible spacing for L-value. With switches open, read and record value of E_0. Close switch in I1 circuit. Read and record current, I1, and voltage, E1. Calculate calibration factor (K) for millivolt shunt using equation shown.
b. With switches open, read and record value of E0. Close switch in I2 circuit. Read and record current, I2, and voltage, E2. Determine difference between E0 and E2.
c. Calculate and record percentage of leakage by equation shown.

C. Cathodic-Protection Systems Using Cast-Iron Anode:
1. Test the following:
a. Hydraulic-elevator well casing: Test casing having cathodic-protection system after pit invert has been constructed. Test each system individually using test stations in elevator pit.
b. Buried chilled-water, steam and condensate piping: Test after backfilling is complete. Test each system individually, using existing test stations along pipeline.
2. Procedures: Perform tests in the following order:
a. Electrical-continuity and insulating-joint tests as specified.
b. Anode tests:
1) Structure-to-anode resistance:
a) Connect instruments as shown.
b) With switch open, record voltage reading 1 on E.
c) Close switch and record voltage and current readings.
d) Reduce current level to less than five amperes by adjusting power source. Record voltage and current readings.
e) Open switch and immediately record voltage as current-off value for potential.
f) Using different values of current and voltage, determine and record resistance using formula shown. Obtain a minimum of three sets of readings to ensure accuracy.
g) Take necessary corrective measures to ensure that resistance is not less than 0.3 ohms.
2) Anode-to-earth resistance:
a) Procedure:
(1) Place copper-copper sulfate reference half-cell at least 50 feet away from anode location and connect voltmeter to read anode-to-earth voltage as shown.
(2) Perform test as specified for structure-to-anode resistance.

b) Acceptance criteria: Actual anode-to-earth resistance not to exceed 20 percent of design soil resistance.
c) Design resistance: As specified in Exhibit 13115-1.
d) Soil resistivity:
(1) If anode-to-earth resistance exceeds 20 percent of design resistance, obtain average soil resistivity in anode-location area.
(2) Make measurements by four-pin method as shown.
(3) Make measurements using suitable resistivity instrument or by battery, voltmeter and ammeter.
(4) Place pins at least 1.5-times pin spacing horizontally from underground metallic structures.

D. Cathodic-Protection Systems Using Magnesium Anode:
1. Test galvanic-anode cathodic-protection system for the following structures and utilities:
a. Buried potable-water, chilled-water and fire piping; sewage-ejector piping; and sewage-pump piping using test stations.
b. Piling: Test structures having cathodic-protection systems. Test each structure individually. Test electrical continuity between piles.
2. Procedures: Perform tests in the following order:
a. Electrical-continuity and insulating-joint tests as specified.
b. Anode tests:
1) Structure-to-anode resistance: Perform test as specified for cathodic-protection systems using cast-iron anode.
2) Anode-to-earth resistance test and soil resistivity: Perform tests as specified for cathodic-protection systems using cast-iron anode.

E. Wire and Cable: Install in accordance with Section 16120.

F. Coal-Tar Epoxy Coating:
1. Subject final coating to spark test for capability of maintaining dielectric integrity at 5,000 volts minimum.
2. Visually inspect coating prior to installation; repair damaged areas in accordance with field-correction recommendations of the coating manufacturer.
3. Backfilling prior to approval of coating is prohibited.

Exhibit 13115-1

G. Design Resistance:

Structure	Soil Resistance	Anodes	Anode-to-Earth Resistance

Exhibit 13115-1 (Cont.)

H. Evaluation:

1. When anode-to-earth resistance exceeds 20 percent of design value, use data from soil-resistivity test to recalculate design resistance.
2. If actual anode-to-earth resistance exceeds recalculated design resistance, install additional anodes as directed.

I. Recalculation: Resistance is calculated by use of the following formulae:

1. Single horizontal anode:

a. $$R_{H\,(N=1)} = \frac{0.00521e}{L}\left\{2.3 \log \frac{4L^2+4L(S^2+L^2)^{0.5}}{dS} + \frac{S}{L} - \frac{(S^2+L^2)^{0.5}}{L} - 1\right\}$$

b. Where:

$R_{H\,(N=1)}$	=	Resistance to earth of the horizontal-ground anode (ohms).
e	=	Effective soil resistivity (ohm-cm).
L	=	Horizontal-anode length (feet).
d	=	Anode diameter (feet).
S	=	Twice anode depth (feet).

2. Single vertical anode:

a. $$R_{V\,(N=1)} = \frac{eK}{L}$$

b. Where:

$R_{V\,(N=1)}$	=	Resistance of single vertical anode-to-earth (ohms).
e	=	Effective soil resistivity (ohm-cm).
L	=	Length of anode (feet).
K	=	Shape function (anode length/ anode diameter) from Table 1.

c. Table 1: The Shape Function:

L/d	K	L/d	K
1	.0056	16	.0201
2	.0092	18	.0207
3	.0113	20	.0213
4	.0128	25	.0224
5	.0140	30	.0234
6	.0150	35	.0242
7	.0158	40	.0249
8	.0165	45	.0255
9	.0171	50	.0261
10	.0177	55	.0266
12	.0186	60	.0270
14	.0194	-	-

3. Multiple vertical anodes in parallel:

a. $R_{V\,(N,S)} = \frac{R_{V\,(N=1)}}{N} + \frac{eP}{S}$

b. Where:

$R_{V\,(N,S)}$ = Resistance-to-earth of vertical anodes in parallel (ohms).

$R_{V\,(N=1)}$ = Resistance-to-earth of single anode (ohms).

e = Effective soil resistivity (ohm-cm).

N = Number of vertical anodes in parallel.

S = Spacing between anodes (feet).

P = Parallel factor from Table 2.

c. Table 2: Parallel Factor:

n	P	n	P
2	.00261	14	.00168
3	.00289	16	.00155
4	.00283	18	.00145
5	.00268	20	.00135
6	.00252	22	.00128
7	.00237	24	.00121
8	.00224	26	.00114
9	.00212	28	.00109
10	.00201	30	.00101
12	.00182	-	-

4. Resistance-to-earth of the horizontal ground bed:

a. $R_{H\,(N,S)} = \frac{R_{V\,(N,S)}}{R_{V\,(N=1)}/N} \times \frac{R_{H\,(N=1)}}{N}$

b. Where:

$R_{H\,(N,S)}$ = Resistance-to-earth of the horizontal ground bed (ohms).

$R_{V\,(N,S)}$ = Resistance-to-earth of N anodes, at spacing S, installed vertically (ohms).

$R_{V\,(N=1)}$ = Resistance-to-earth of single vertical anode (ohms).

$R_{H\,(N=1)}$ = Resistance-to-earth of single horizontal anode (ohms)

N = Number of anodes.

END OF SECTION

SECTION 13905

FIRE PROTECTION, SUPPRESSION AND ALARM

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing dry standpipe, wet standpipe, sprinkler, exterior fire protection and clean agent fire-suppression systems.

B. Related Work Specified Elsewhere:
1. Water distribution system: Section 02515.
2. Storm and sanitary system: Section 02535
3. Firestopping: Section 07841.
4. Field painting: Section 09920.
5. Corrosion control system: Section 13115.
6. Identification of mechanical equipment and piping: Section 15075.
7. Piping system: Section 15205.
8. Control equipment: Section 15900.
9. Grounding and bonding: Section 16060.
10. Wire and cable: Section 16120.
11. Raceways, boxes and cabinets: Section 16130.

C. Description of System:
1. Dry standpipe system: Consists of siamese fire-department connection, dry fire line, check valves, automatic air vents, drain valves and angle hose valves.
2. Wet standpipe system: Consists of siamese fire-department connection, wet fire line, check valves, drain valves, fire water-line surveillance valve, angle hose valves and capped branch connections for sprinkler systems where shown.
3. Fire-suppression system for entrance escalators: Consists of fire line to point inside entrance escalator pit/machine room capped for future extension by escalator contractor, supplied from wet standpipe system.
4. Sprinkler system, other than escalator: Consists of sprinkler lines, fire water-line surveillance valve, flow-alarm check valve, drain valve, and sprinkler heads as well as heating tracers in areas subject to freezing temperatures, supplied from wet standpipe system or from domestic water line as shown.
5. Exterior fire-protection system: Consists of lead-ins to wet standpipe system, valves and accessories, supplied from the city water main.
6. Automatic, total-flooding clean agent suppression system: Consists of smoke detectors, agent storage containers, nozzles, clean agent suppression system control and detection panel, manual pull station, alarm bell, evacuation horn, clean agent suppression system discharge visual alarm and necessary interface boxes for signals from and to HVAC and communications. Each room or hazard area to have its own system designed to provide a concentration of 7 percent by volume.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: A5.13
3. FM Approval Guide.
4. NFPA: 12A, 13, 14, 15, 24, 2001.
5. UL: 262, 312, 1479, Fire Protection Directory.
6. ANSI/ASME: B16.1, B16.5, B16.9, B31.1.

7. ANSI: Z535.1.
8. NEMA: 250.
9. FS: A-A-1992 SS-C-153, WW-P-421, WW-P-501, WW-U-516, WW-U-531.
10. MSS: SP-58.
11. ASTM: A36, A47, A53, A135, A183, A234, A 240, A276, B766, D1752, D2000.

B. Qualification of Welding Personnel: Section 05120.

C. Design Criteria:
1. NFPA 12A, 13, 14, 15 and 2001 as applicable.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
a. Methods of joining, welding, fastenings, and anchoring.
b. Materials and locations for wet standpipe, dry standpipe, sprinkler, clean agent suppression and external systems.
c. Pipes and piping layout, including pipe hangers and supports.
d. Pipe hangers and supports.
e. Valves.
f. Escutcheons.
g. Gauges.
h. Automatic air vents.
i. Pipe sleeves.
j. Mechanical couplings.
k. Layout of sprinkler and clean agent suppression systems and detail drawings approved by Fire Marshal of jurisdiction in which work is to be performed.
l. Reports covering test materials.
2. Certification:
a. Fire line test results.
b. Manufacturer's certification that pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified and that couplings are designed and tested as specified.
3. Samples: Paint, Section 09920.
4. Operation and Maintenance Manuals.

1.04 JOB CONDITIONS:

A. Do not perform welding when the temperature of the base metal is less than zero degree F.

B. Do not perform welding when surfaces are wet or during periods of high winds unless operator and work are properly protected.

C. Environmental Requirements: Paint, Section 09920.

1.05 OPERATION AND MAINTENANCE TRAINING:

A. Upon completion of installation and in accordance with the General Requirements furnish for a period of not less than two consecutive man-days services of a manufacturer's field engineer with specialized experience in the components of the system to instruct Authority personnel in the proper operation and maintenance of the systems.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. General Requirements:
1. In design and purchase of equipment, provide for interchangeability of items of piping and electrical equipment sub-assemblies, parts and relays.

B. Pipe and Fittings:
1. Exterior fire-protection system:
a. Ductile-iron pipe and fittings:
1) Piping embedded or otherwise inaccessible: FS WW-P-421, Type III, Grade C, 250-pound pressure class.
2) Piping from point of connection to inside of structure: FS WW-P-421, Grade C, 250-pound pressure class, flanged. Flanges: ANSI B16.1.
3) Pipe coated on outside with bituminous coating and lined with cement mortar of twice standard thickness specified for pipe size used.
a) Cement-mortar lining having seal coat of nontoxic, tasteless and odor-free bituminous material.
4) Neoprene gaskets furnished for joints.
2. Interior fire-protection system:
a. Fire lines, embedded or otherwise inaccessible:
1) Pipe: Galvanized steel, ASTM A53, Type E ,Grade B, with the following additional requirements:
a) Fire-protection piping: Extra-strong weight, Schedule 80.
2) Fittings and flanges: Galvanized, furnished with wall thickness equal to or greater than that of adjacent pipe, with the following additional requirements:
a) Fire lines: ASTM A234, Grade B, and ANSI B16.9 for dimensions and tolerances.
(1) Flanges: ASTM A234 and ANSI B16.5 for dimensions and tolerances.
b. Fire lines, exposed or otherwise accessible:
1) Pipe:
a) Galvanized steel: One of the following:
(1) ASTM A53: One of the following:
(a) Type E, Grade B.
(b) Type F, Grade A.
(2) ASTM A13
b) Welded or seamless.
c) Standard weight, Schedule 40, with grooved ends. Use of Schedule 10 pipe is not allowed.
2) Mechanical joint couplings: Keyed for joining grooved-end piping.
a) Coupling housing: Malleable iron in accordance with ASTM A47, Grade 32510, galvanized, fabricated in two or more parts enclosing resilient gasket seal, with keys to fit machined grooves on pipe ends. Rated at 300-psig minimum pressure and factory-finished with manufacturer's standard paint coating.
b) Coupling gasket: Chlorinated butyl, ASTM D2000, specification 3-BA-615-A14-B13, with following additional requirements:
(1) Molded grooves.

(2) Pressure-responsive seal, integrity increasing with internal pressure.

c) Coupling bolts and nuts: Oval-neck track-type bolts with hexagonal nuts conforming to ASTM A183 permitting single-wrench assembly, having minimum tensile strength of 110,000 psi, with cadmium-plated finish ASTM B766, Type III.

3) Fittings:

a) Grooved-end, fabricated of malleable-iron casting in accordance with ASTM A47, Grade 32510, galvanized; nonstandard fittings fabricated from Schedule 40 steel pipe.

b) Mechanical branch outlets:

(1) Victaulic 920 or equal.

(2) Victaulic Style 72 or equal.

c) Threaded pipe fittings: FS WW-P-501, Type 1, Class B.

d) Welding fittings made of same wall thickness as pipe.

(1) Factory-made welding fittings.

(2) Mitered-joint elbows and field-made reducers are prohibited.

e) Butt-welded fittings larger than 1-1/2 inches: ANSI B16.9.

f) Flanges for welded piping system: ANSI B16.5, galvanized forged steel, welded-neck type, 175 pressure class for stations and 250 pressure class for tunnels.

4) Paint, Primer, and Undercoat: Alkyd Semigloss System as specified in Section 09920, Color: OSHA Red (Safety Red) in compliance with ANSI Z535.1 for piping, White for stenciling.

c. Unions: WP 175 psig.

1) 1-1/2 inches and smaller: Threaded, FS WW-U-531, Type B to match piping.

2) Two inches and larger: Flanged.

a) Two union flanges, 2-1/2 and three inches: Steel, FSA WW-U-531, or cast iron, ANSI B16.1.

3) Four inches and larger: Forged steel, slip-on weld neck flanges, ANSI B16.5.

4) Nonferrous piping unions: Brass, FS WW-U-516.

C. Valves:

1. Fire-line valves, outside stem and yoke (OS&Y), UL Fire Protection Directory listed or FM Approval Guide listed for 175-psig minimum, meeting requirements of listed NFPA Standards, with UL or FM symbol cast or stamped on valve body.
2. Gate valves: UL 262 or FM Approval Guide listed, 175-psig WP
3. Check valves: UL 312 or FM Approval Guide listed, 175-psig WP, flanged-end connections, swing-type, metal-to-metal, rubber-faced or equivalent, valve seat 15 degrees from perpendicular to direction of flow.
4. Sprinkler flow-alarm check valves: Designed to operate on 10 gpm or more with restriction bypass which allows restricted flow of water to pass from supply to system side of alarm-valve clapper, to decrease possibility of false alarms resulting from increase in supply water pressure or from water hammer.
   a. Furnished with retarding chamber, test and drain connections and electric contact unit.
   b. Cast-iron bodies with nonferrous-metal seat, rings, bearings and renewable clapper facing.
   c. Contacts: Section 15900.
5. Fire water-line surveillance valve:

a. Double-disc, solid-wedge gate-type with outside stem and yoke (OS&Y) and renewable ring seats.
b. Designed for position indicator contact:
1) Contacts open with valve fully open.
2) Contacts close and alarm condition is initiated with two turns of hand wheel or when valve stem has moved one-fifth of distance from normal fully open position.

6. Sprinkler alarm check-valve surveillance: Contact closes on flow amounting to 10 gpm or greater.
7. Ball drip valves: 3/4 inch, threaded both ends and rated at 175-psig minimum.
8. Air and vacuum valves:
a. Automatic.
b. High-capacity; minimum flow, 3.0 cfs; pressure differential, 5.0-psig maximum.
c. Designed for maximum system working pressure; 175-psig minimum; suitable for working pressures from zero psig to maximum capacity.
9. Angle hose valves:
a. Cast bronze, male outlet, replaceable rubber disc and rising stem.
b. Rough-bronze body, polished-finish bonnet, nut and stem, complete with cap and chain.
c. Cast-iron or aluminum hand wheel, red-enameled.
d. Working pressure: 200 psig.
e. UL Fire Protection Directory listed with symbol cast or stamped on valve body.
f. American National Standard Fire Hose threads.
10. In-line cut-off valves:
a. Flanged gate valve, with outside stem and yoke
b. Comply with UL 262, UL Fire Protection Directory listed or FM Approval Guide listed with symbol cast or stamped on valve body.
c. Working pressure, 175 psig.
d. Cast-iron or aluminum hand wheel, red-enameled.

D. Fire Department Siamese Connection:
1. Free standing:
a. Paved areas: Double clapper, with sidewalk sleeve, sidewalk plate, two rocker-lug plugs and chains, polished brass, two female inlets with 2-1/2 inch American National Standard Fire Hose Threads, UL Fire Protection Directory listed or FM Approval Guide listed, working pressure of 200 psig and with cast recessed Type B Metro logo and inscription, as shown, except inside fenced Authority property.
b. Landscaped areas: As specified for paved areas, except no sidewalk sleeve or plate.
c. Paint, Primer, and Undercoat: Alkyd Semigloss System as specified in Section 09920, Color: OSHA Red (Safety Red) in compliance with ANSI Z535.1 for piping, White for stenciling.
2. Wall-mounted: Double clapper rectangular wall plate for flush mounting, two rocker-lug plugs and chains, polished brass, two female inlets with 2-1/2 inch American National Standard Fire Hose Threads, UL Fire Protection Directory listed or FM Approval Guide listed, working pressure of 200 psig, and with cast raised Type B Metro logo and inscription as shown. Provide sill cock where necessary for drainage.

E. Sprinkler Heads:
1. Standard fusible-link type.
2. Bronze finish, exposed and temperature rating of 165F in accordance with listed NFPA Standards.

F. Sprinkler Test Connections:
   1. Drain piping, valves and fittings necessary for testing in accordance with listed NFPA Standards.

G. Control System: Except as specified for clean agent suppression systems: Provided by others.

H. Supporting Devices:
   1. Pipe hangers and supports:
      a. Adjustable, stainless steel, clevis-type, threaded full length, with diameter consistent with pipe size and the load imposed: MSS SP-58.
      b. Hanger rods: 3/8-inch minimum diameter, stainless steel, ASTM A276,Type 304, threaded full length, with diameter consistent with pipe size and the load imposed: MSS SP-58.
      c. Nuts and washers: Stainless steel.
      d. Supported from stainless steel inserts in concrete slab: MSS SP-58.
   2. Adjustable U-bolt type:
      a. U-Bolt: Fabricated from stainless steel, MSS SP-58.
      b. Nuts and washers: Stainless steel..
      c. Chair: Cast iron or fabricated from stainless steel.
   3. Z-bar: Fabricated from stainless steel: ASTM A240, Type 304.
   4. Pipe anchors:
      a. Designed to withstand a minimum of five times anchor load.
      b. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.
   5. Expansion-bolt anchors:
      a. Consisting of bolt, expander, star lock washer and nut.
      b. Fabricated of stainless steel, Alloy S30300 in accordance with ASTM E527, including expander and star lock washer.
      c. Anchor assemblies: FS A-A-1992, Group II, Type 4, Class 1.
   6. Self-drilling anchors:
      a. Self-drilling, expansion anchors with self-cutting annular broaching grooves.
      b. Anchor and expander plug: Double-plated, FS A-A-1992, Group III, Type 1.
   7. Pipe sleeves:
      a. Through interior masonry-unit walls: PVC, as shown, large enough to accommodate pipe but minimum two sizes larger than pipe size.
      b. Through cast-in-place concrete interior walls and concrete ceilings: Factory-made cast iron with anchor flange and cast-iron plate collar screw-fastened to slab and pipe.
         1) Sleeves minimum two sizes larger than pipe; for floors and ceilings projecting four inches above finish floor.
      c. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.
      d. Sleeves designed for pipe-movement allowance due to expansion and contraction.
   8. Escutcheon plates:
      a. Polished brass or stainless steel, screw-fastened to wall or ceiling.
      b. Plate collars caulked with silicone sealant or intumescent putty.
      c. Sealant: UL-1479.

I. Pressure Gauges: Spring pressure-type, 3-1/2 inch dial, in accordance with NFPA 14.

J. Bonding Strap: 2AWG single-conductor cable: Section 16060.

K. Preformed Joint Filler: ASTM D1752.

L. Coal-Tar Epoxy: Section 02535.
   1. Thinner of type recommended by manufacturer of coating and used only when approved.

M. Water-Flow Indicator: Vane-type water flow switch, UL Fire Protection Directory listed, FM Approval Guide listed. Electrical rating: 24 volts dc, 1.5 amperes, normally open contacts to actuate with flow of 10 gpm or more.

N. Clean agent suppression system:
   1. Smoke detectors: Products of combustion, dual-chamber, ionization-type, operating voltage of 22 to 28 volts dc, 30 milli-amperes (ma) standby current drain at 24 volts dc and alarm current drain of 60 ma at 24 volts dc. Three amperes minimum alarm contact rating at 24 volts dc. Detector will activate alarm approximately five seconds after product of combustion particulate enters ionization chamber. Detectors equipped with indicator lamp which will remain lighted until reset. Unit listed by UL Fire Protection Directory and FM Approval Guide as signal and release device.
   2. Manual pull station: Contained in cast-metal housing for mounting on standard four-inch junction box unit to have dual-action release configuration such as discharge lever protected by lift cover, to prevent accidental discharge, and tamper-resistant screw to prevent unauthorized access to reset procedure. For operation at 24 volts dc. Listed by UL Fire Protection Directory as release device.
   3. Abort switch: A momentary, normally closed push-button switch. Time delay to restart at designated setting when abort switch is released. Switch to be accessible and labeled 'CLEAN AGENT ABORT.' Activation of the abort switch to silence discharge warning horn.
   4. Clean agent suppression system control equipment:
      a. Control panel: Multizone for operation by smoke detectors and manual pull station, singly or in combination, to activate prealarm or release of agent as required. Power source for operating extinguishing system as well as specified auxiliary functions.
         1) Panel enclosure: NEMA 250, Type 1 surface-mounted, dead front; indicators and control switches visible, mounted on panel behind hinged, locked glass-paneled door, complete with relays, trouble and alarm bell, silencing switch with ring-back feature, LED indicating lamps, nameplates, switches and terminals to provide relays for fire-alarm system tie-in, for HVAC systems fan shut-down, HVAC-damper closing, for test delay switch with automatic reset to permit testing fire-alarm system without activating auxiliary control functions.
         2) Operating circuitry: Solid-state electronics with plug-in circuit modules for detection and release circuits; 120-volt ac, 60-Hertz supply; 24 volts dc signal and release circuits including power for operating extinguishing sub-system and other functions. Power consumption 10 watts steady state, 200 watts peak.
         3) Functional circuitry: Provide two detection zones and two output circuits for signal and release, all Class B supervised. Detection circuits to accommodate smoke detectors and manual stations intermixed. Signal output circuit of the polarity-reversal type. Release circuit to include supervised abort switch and adjustable time delay. Provide separate relay output for each zone alarm, general alarm, trouble, predischarge and system-fired circuit; utilize 10-ampere contact.
         4) Operation: Activation of detector, circuit to light zone alarm lamp on indication panel, sound audible local alarm, activate the extinguisher system and energize auxiliary relays for remote alarm

or equipment shut-down. Loss of dc power or discontinuity in detection circuits to light trouble lamp on indicator panel and actuate bell alarm; provide trouble bell silence switch with ring-back circuit to silence trouble bell alarm. Receipt of zone alarm to override trouble alarm. A single switch to reset control unit.

5) Indicator lights, as follows:
   a) POWER ON: Green.
   b) TROUBLE: Yellow.
   c) ALARM ZONE 1: Red.
   d) ALARM ZONE 2: Red.
   e) PRE-DISCHARGE: Red.
   f) SYSTEM FIRED: Red.

b. Extinguishing system:

1) Provide system designed to discharge seven-percent volume concentration of extinguishing agent with discharge not to exceed 10 seconds. The system to comply with NFPA 2001. Each extinguishing system to include the following
   a) Agent storage container: Container fabricated of high-strength alloy steel with burst-disc actuator valve assembly, safety plug, cable assembly, 0 - 600-psig pressure gauge, pressure switch and lifting ring. Container to conform to applicable DOT specifications; to automatically relieve between 850 psi and 100 psi in event of excessive pressure buildup. Super-pressurize filled container with dry nitrogen to 390 psig at 70F to assist rapid distribution. Container designed for on-site reconditioning and refilling. Actuator valve assembly to be an integral part of container.
   b) Discharge nozzle: Provide series of one-piece, nonclogging nozzles to distribute agent in protected volume. Nozzle size selection determined by container size and geometry of volume to be protected. Nozzles connected through reducer, elbow and piping. Nozzle discharge pattern to deliver uniform agent coverage to all areas of enclosed hazard.
   c) Actuator: Electrical device to operate on demand to provide path for relief and discharge of agent.
   d) Mounting bracket: Designed for wall-mounting agent storage container and capable of withstanding 1,000-pound thrust for five seconds in any direction.
   e) Agent: Liquefied compressed clean agent suppression system conforming to requirements of NFPA 2001.
   f) Alarm bell: Motor driven, with six-inch gong, 24-volt dc operating voltage, 90 dBA sound-pressure level at one meter and OSHA Safety Red finish.
   g) Evacuation horn: Vibrating, 24-volt dc, 0.063 amperes, 97 dBA sound-pressure level at one meter.
   h) Discharge indication light: Flashing device with legend CLEAN AGENT DISCHARGE; 24-volt dc.
   i) Clean agent suppression system interface box: Data-transmission system (DTS) cabinet specified in Section 16130, with the following additional requirements:
      (1) Cabinet: Hoffman A161206LP.
      (2) Terminal strip: 16 terminals minimum.
      (3) Exterior finish color: OSHA Safety Red.
      (4) Identify cabinet on cover with COMMUNICATION INTERFACE in one-inch high yellow letters.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances to space provided and make serviceable.

B. Provide support beams, concrete pads, platforms, and hangers necessary for proper installation of equipment as recommended by manufacturer.

C. Install complete fire-protection systems as shown and as specified. During installation, protect work, equipment, and materials. Plug or cap pipe openings.

D. Flush underground mains before connection to wet-standpipe risers at following minimum flow rates:
1. Six-inch pipe: 750 gpm.
2. Eight-inch: 1,000 gpm.
3. 10-inch pipe: 1,500 gpm.
4. 12-inch pipe: 2,000 gpm.

E. Fasten escutcheon plates to wall or ceiling. Seal plate collars watertight with mastic.

F. Welding Procedure:
1. As specified in Section 05120, with the following additional requirements:
   a. Manual metallic arc process, except for pipe sizes four inches and smaller where oxyacetylene welding may be used.
      1) Use electrodes and rods of composition recommended by AWS A5.13 for pipe.
      2) Heat surface within three inches from point where weld will start to a temperature warm to hand before welding.
   b. Leave joint surfaces smooth, uniform and free from fins, tears and other defects which adversely affect proper welding.
   c. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.
   d. Peen with light blows of blunt-nosed peening hammer. Do not peen surface layers or first pass in groove welds.
   e. For groove welds, center surface pass substantially on seam, smooth and free from depressions.
   f. Fillet weld with minimum cutting back of outside surface of pipe.
      1) Leave throat of full fillet weld not less than 0.707 of thickness of pipe.
      2) Repair excess cutting back and undercutting of base metal in pipe adjoining the weld.
      3) Fill craters to full cross section.
   g. Position pipes to be welded so that joints will be in alignment. Joints misaligned more than 20 percent of pipe wall thickness or maximum of 1/8 inch are prohibited.
   h. Install welding pipe in accordance with ANSI B31.1.
2. Cut ends of screw-jointed pipes squarely to seat in bottom of recess of fittings. Ream after cutting so waterway is not reduced in size.
3. Apply thread dope or compound to male thread only.
4. Where cathodic protection is shown, apply coal-tar epoxy coating as specified in Section 02535 and test as specified in Section 13115.

G. Buried Ductile-Iron Pipe: Install as specified in Section 02515, except use mechanical joints.

H. Steel-Pipe Installation:
1. Maintain OSHA required head clearance.
   a. Install horizontal piping with minimum pitch of one inch in 40 feet.
   b. Provide drains at low points: Minimum 3/4-inch valves with hose connection.
   c. Install vertical pipes near wall from which they are supported.
2. Make connections to equipment without placing strain on piping and equipment.
3. Tunnel, vent and fan-shaft piping:
   a. Joints of the following types:
      1) Butt weld joints in pipe recessed in tunnel lining.
      2) Use mechanical grooved couplings for remainder of joints in horizontal and vertical mains unless otherwise shown.
      3) Use threaded joints in branch lines 2-1/2 inches or smaller.
   b. Provide number of mechanical couplings necessary to allow minimum 1-1/4 inch expansion per 100 feet of main.
   c. Use reducing tee for mechanical couplings or mechanical branch outlet at main-to-branch connections.
   d. Make in-line cut-off valves accessible from floor or walkway level.
4. Underplatform station piping:
   a. Provide the following types of joints or couplings:
      1) Couplings: Mechanical, grooved, at intervals not to exceed 21 feet.
      2) Where possible, cut grooves before galvanizing.
      3) Where grooves are cut after galvanizing, apply zinc coating.
      4) Other joints:
         a) In lines four inches and larger: Welded joints.
         b) In lines less than four inches: Welded or threaded joints.
   b. Provide anchors, horizontally and vertically rigid, within one foot of one end of each length of pipe jointed with Victaulic-type mechanical couplings. Provide clevis-type support within one foot of other end, at midpoints between mechanical couplings and at each angle hose valve. Locate supports at angle hose valves to ensure resistance to rotation of valves and adjacent piping by water pressure at valve. Provide restraint for every third length of pipe to prevent excessive movement by a horizontal thrust. Roller-type hangers and pipeline guides are not required
5. Other station piping: Joints in balance of station fireline piping of mechanical-type, grooved or welded couplings for lines four inches and larger and screwed or welded for lines under four inches, except that mechanical-type groove couplings must be accessible.

I. Mechanical-Type Groove Couplings: Install couplings according to manufacturer's instructions and as follows:
1. After grooving, remove indentations, projections and roll warps as necessary. Cut pipe ends square to tolerance of plus-or-minus 0.03 inch. Provide zinc coating on exposed surface.
2. Lightly coat pipe ends and coupling gasket with non-petroleum-based lubricant.
3. Center gasket, install housing and ensure that keys are securely located in pipe grooves.
4. In underplatform station piping, provide separation of 1/8 inch between ends of adjacent sections of pipe within coupling, based on air temperature of plus 60F. Adjust based on actual air temperature at time of installation.
5. Install bolts and nuts tightened uniformly to manufacturer's recommended limits using torque wrench, without pinching gaskets.
6. Provide bonding across couplings for stray-current protection.

J. In-Line Valves: Install in-line valves by bolting fitting to valve and welding fitting to pipe.

K. Pipe Anchors: Securely anchor piping as specified, where shown and where necessary for proper installation to force pipe expansion in proper direction.

L. Expansion-Bolt Anchors: Drill holes and install expansion-bolt anchors in manner recommended by anchor-bolt manufacturer. Do not install less than eight inches from concrete edge.

M. Pipe Sleeves: Fill annular space between pipe and sleeves with preformed joint filler, tightly placed to form effective seal against groundwater.

N. Bonding: In accordance with Section 16060, and with the following additional requirements:
1. Bond mechanical joints and fittings, including valves, by exothermic-welding method.
2. Make welds in accordance with manufacturer's recommendations. Clean and coat with coal-tar epoxy.
3. Bond pipe using bonding strap welded to each side of joint not less than six inches from joint. Allow sufficient slack in conductor for expansion of pipe.

O. Air Vents: Install high-capacity automatic air vent(s) at opposite end(s) of dry-standpipe system from fire-department siamese connection or where shown. Pipe air-vent outlet to nearest drain or as directed.

P. Firestopping: Section 07841.

3.02 PROTECTION OF PIPING AND EQUIPMENT:

A. Protect pipe, openings and valves from dirt, foreign objects and damage during construction.

B. Replace damaged piping, valves and other appurtenances, should damage occur prior to final acceptance of the work.

3.03 FIELD QUALITY CONTROL:

A. Field Tests:
1. Flush piping with water until clean and free of scale, slag, dirt, oil, grease and other foreign material.
2. Perform final testing, acceptance, and certification in accordance with NFPA 13, 14, and 24, as applicable.
3. Test electrical continuity of bonded joints by measuring resistance. Total resistive value of joint not to exceed calculated resistance of bond cable plus 10 percent.

B. Water-Pressure Testing:
1. In the presence of the Engineer, test piping, prior to burial or concealment, using specified procedures specified.
2. In the presence of the Engineer, completely test piping system for leaks until approved.
3. Notify the Engineer at least 36 hours prior to tests.
4. Test piping at the following pressures:
   a. Fire-protection piping, inaccessible: 400 psi-minimum.
   b. Ductile-iron pipe: At lowest point in system, 150 psi or 1-1/2 times maximum working pressure, whichever is greater.
   c. Fire-protection piping, exposed and accessible: At lowest point in system, 150 psi or 1-1/2 times maximum working pressure, whichever is greater.

C. Test Procedures:
1. Test fire-protection piping in accordance with NFPA.
2. Fire-protection piping, inaccessible:
a. Avoid excessive pressure on safety devices and mechanical seals.
b. Fill entire system with water and vent air from system at least 24 hours before test pressure is applied.
c. Apply test pressure when water and average ambient temperature are approximately equal and constant.
d. Maintain test pressure for six hours minimum without drop after force pump has been disconnected.
3. Water-test entire system with pressure at highest point of 250 psig.
4. After filling system, shut off water supply and allow it to stand for two hours under test without loss or leakage.
5. Coordinate with and assist local fire department in performing flow tests. After performing hydrostatic test, drain water from firelines. Perform flow test at rate of 500 gpm with pumper connected to siamese connection, starting testing with sudden full flow into empty firelines.
6. Drain system immediately after hydrostatic and flow testing.

D. Repair of Leaks:
1. The following are prohibited:
a. Repair of leaks by mechanical caulking.
b. Introduction of material inside piping system to stop leakage.
2. Repair leaks in threaded piping by breaking joint, cutting new threads on pipe and installing new pipe fitting.
3. Coat field welds and repair damages to zinc-coated surfaces as follows:
a. Wire brush areas to be coated to bright metal.
b. Apply galvanizing repair compound at rate of two ounces per square foot.
4. Replace defective coupling assembly as necessary.
5. Remove defective welds by chipping or gouging.
a. Reweld the chipped-out places.
b. When base metals of fillet welds are cut back or throat of welds are less than specified, repair defect by adding additional weld metal.

3.04 CLEANING:

A. Flush firelines with water to remove sediment after completion of tests, repairs or replacements.

B. Disinfect firelines connected to potable-water system as follows:
1. Use chlorine for disinfection in form of hypochlorite solution or in form of compressed gas applied through approved chlorinator.
2. Operate valves and equipment during chlorination to ensure that chlorine reaches entire system.
3. Feed water and chlorination agent into system at rate providing for 50 ppm of chlorine and allow to stand 24 hours before flushing.
4. Residual chlorine, at end of 24-hour retention period, not less than 10 ppm.
5. Flush treated water from system completely after disinfection.
6. Continue flushing until samples show that quality of water delivered is comparable to public water supply and satisfactory to public-health authority having jurisdiction.
7. Do not take samples from hydrants or through unsterilized hose.

3.05 FIELD PAINTING: Section 09920.

A. Prepare piping, apply primer, undercoat and finish coats in accordance with Section 09920.

3.06 IDENTIFICATION OF PIPING AND VALVES: Section 15075.

3.07 CLEAN AGENT SUPPRESSION SYSTEM:

A. General:
1. Install clean agent suppression system sized and adjusted to discharge seven-percent concentration within protected spaces in accordance with NFPA 2001. Smoke detectors to be cross-zoned so that at least one detector from each loop shall react to smoke before extinguishing system will be activated. First detector actuated to sound alarm bell, illuminate indicator lamp for appropriate alarm zone and energize fan shut-down relays and close dampers of HVAC systems serving involved space. Second detector actuated to energize evacuation time-delay relay in clean agent suppression system control panel, sound evacuation horn and illuminate SYSTEM FIRED indicator light at clean agent suppression system control panel to indicate system discharged. Actuation of manual pull station to by-pass time-delay function, sound evacuation horn, energize fan shut-down relays of HVAC system serving area and release FM200.

B. Trouble Operation:
1. Opens or ground in wiring to ring bell on FM200 control panel. Silencing switch to silence trouble bell during correcting of fault.

C. Remote Alarms:
1. Activation of the following to generate alarm indicators at clean agent suppression system control panel:
   a. Alarm Zone 1.
   b. Alarm Zone 2.
   c. System fired.
   d. Trouble.

D. Performance Testing:
1. Performance-test completed system except smoke detectors.
2. Provide instrumentation and test gases-test systems including detection system in accordance with jurisdictional requirements.
3. Operate mechanical and electrical systems.
4. Inspect nozzles and agent storage containers.
5. Full equivalent test of gas discharge into each zone area. Use meter to verify delivery of specified concentrations within required time and maintained for minimum of 10 minutes.
6. After completion of satisfactory testing, refill storage containers.

END OF SECTION

SECTION 14200
IN- GROUND HYDRAULIC ELEVATORS
PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section specifies work pertaining to heavy-duty hydraulic passenger elevator systems including elevator cars, hoistway equipment, hydraulic piping, valves, cylinders, machinery, control systems, indicators, signs, elevator pit ladders, and finish work in the vicinity of the hoistway doors. Work under this section also includes drilling of casing holes, furnishing, and installation of 3/8-inch thick steel well-hole casings, and concrete in the bottom of the well hole.

B. The following sections include related requirements and are performed by other trades:

1. Section 02205 – Removal and Restoration of Existing Facilities
2. Section 05500 – Metal Fabrication
3. Section 08800 – Glass and Glazing
4. Section 09920 – Field Painting
5. Section 07170 – Bentonite Waterproofing
6. See Division 15 for heating, ventilation, air conditioning, and/or fire suppression requirements for elevator machine room.
7. See Division 16 for operation and maintenance of electrical service to elevator equipment, fire alarm systems, and communications systems.

1.03 REFERENCES

A. Codes, Regulations, Reference Standards, and Specifications

Elevator Code of the local jurisdictions hereinafter referred to as the “Code”

Comply with codes and regulations of the Authority Having Jurisdiction.

1. ASME A17.1 - Safety Code for Elevators and Escalators Includes Requirements for Elevators, Dumbwaiters, Moving Walks, Material Lifts, and Dumbwaiters with Automatic Transfer Devices.
2. ASME A17.2 - Guide for Inspection of Elevators, Escalators and Moving Walks Includes Inspection Procedures for Electric Traction and Winding Drum Elevators, Hydraulic Elevators, Inclined Elevators, Limited-Use/Limited-Application Elevators, Private Residence Elevators, and Escalators and Moving Walks
3. ASTM A36/A36M – Standard Specification for Carbon Structural Steel
4. ASTM A123/A123M – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
5. ASTM A153/A153M – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

6. ASTM A240/A240M REV B – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
7. ASTM A264 – Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate
8. ASTM A276/A276M – Standard Specification for Stainless Steel Bars and Shapes
9. ASTM A500/A500M – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
10. ASTM A653/A653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galv-annealed) by the Hot-Dip Process
11. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire
12. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
13. ASTM D471 – Standard Test Method for Rubber Property-Effect of Liquids
14. AWS D1.1/D1.1M ERTA – Structural Welding Code - Steel
15. ICC A117.1 – Accessible and Usable Buildings and Facilities
16. IEEE 1202 CORR 1 – Flame-Propagation Testing of Wire and Cable Corrigendum 1
17. NEMA C80.1 – Electrical Rigid Steel Conduit
18. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
19. NEMA KS 1 – Heavy-Duty Enclosed and Dead-Front Switches (600 Volts Maximum)
20. NEMA MG 1 – Motors and Generators
21. NEMA PB 1 - Panelboards
22. NEMA WC 70 – Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
23. NFPA 13 – Standard for the Installation of Sprinkler Systems
24. NFPA 70 – National Electrical Code
25. NFPA 72 – National Fire Alarm and Signaling Code
26. NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems
27. UL 6 – Electrical Rigid Metal Conduit - Steel
28. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations
29. UL 62 - Flexible Cords and Cables
30. UL 98 - Enclosed and Dead-Front Switches
31. UL 360 - Standard for Safety Liquid-Tight Flexible Metal Conduit
32. UL 486A-486B - Wire Connectors
33. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
34. UL 514A - Metallic Outlet Boxes
35. WMATA Design Criteria requirements are indicated in Section VI-Mechanical.
36. Any additional requirements imposed by local agencies and/or codes having jurisdiction shall be incorporated into elevator installation.
37. In the event of a conflict between codes, regulations or standards, the most stringent requirement as determined by the Contractor and approved by the Authority shall take precedence unless specifically addressed herein.

B. Definitions

All terms in this specification have the meaning as defined in the ASME code.

1. Heavy Duty Elevator: An elevator designed specifically for the harsh environment and duty load cycles common to transportation system usage.
2. Elevator: A hoisting and lowering mechanism, equipped with a car or platform, which moves in guide rails or racks and serves two or more landings
3. Elevator, Passenger: An elevator used primarily to carry persons other than the operator and persons necessary for loading and unloading.
4. Elevator, Hydraulic: Power elevator in which the energy applied, by means of a liquid under pressure, in a hydraulic jack.
5. OEM: Original Equipment Manufacturer.
6. Dwell Time: The period of time the elevator is at a landing while the doors open, passengers transfer, and doors close.
7. Elevator Substantial Completion: The point at which the elevator is ready for use, whether the site is finished or not. This is where the jurisdictional inspection usually takes place.
8. Elevator Final Acceptance: The point at which the owner accepts the project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
9. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.
10. Beneficial Use: When the elevator is placed into service, may be prior to the site being ready for public use.
11. Revenue Service: The station or facility opening date.
12. Override Switch: A switch located in a kiosk panel, which disables the Hall Call Buttons.
13. SDS: Safety Data Sheet
14. BOM: Bill of Material
15. Elevator MCP: Maintenance Control Program as defined in the ASME A17.1 Code.
16. SMNT: WMATA Office of Systems.
17. ICC: International Code Council
18. NIST: National Institute of Standards and Technology
19. NESC: National Electrical Safety Code
20. NEII: National Elevator Industry, Inc.
21. SPI: Society of the Plastics Industry
22. NAAMM: National Association of Architectural Metal Manufacturers

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. The Manufacturer shall provide documents stating that their firm has successfully produced elevators for transit system applications for a minimum of ten (10) years and regularly engaged for the past five (5) years in the manufacture of major components for hydraulic passenger elevators. As a standard of quality, the elevator equipment design and installation shall comply with the Code.

B. Installer's Qualifications

1. The Installer shall be the original manufacturer of elevator equipment or manufacturer's authorized agent who is trained and approved for installation of units required for this Project.
2. The Contractor shall obtain and pay for all permits and licenses and perform all required inspections.

C. Elevator Contractor

1. The Elevator Contractor shall guarantee the materials and workmanship of the apparatus furnished under these specifications and will correct any defects not due to ordinary wear and tear within two (2) years from date of completion of each elevator, inclusive of labor and traveling expenses. Defective work shall be repaired or replaced at no additional cost to the Authority.

D. Welding

1. Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of the current certification by AWS or CWB.

E. Labeling Requirements

1. Every elevator shall be clearly marked with rated load, speed, manufacture serial number, and the designated Authority identification.
2. All elevators shall be permanently numbered with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the elevator numbers shall be submitted for WMATA ELES Engineering. The elevators shall be numbered in sequence, starting at the north entrance left to right facing to the elevator at each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the platform. Corresponding numerical identification shall be affixed to the equipment in the machine rooms. The elevator numbering shall be approved by the ELES Engineering representative.

F. Work by Other Trades

1. The hoistway shall conform to code and specified requirements, plumb to within one quarter (¼") inches, including machine beams, pit, and pit ladders.
2. Intermediate rail bracket supports.
3. Grouting around hoistway entrances and sills.
4. Temporary and Permanent Electrical Power Services
5. The Contractor shall provide and coordinate the following:
    a. For the elevator drive systems: 480V (460V), 3 phase, 3 wires, 60 Hz terminating in a disconnect switch within sight of the controller. The disconnect switch shall be free of any obstruction for a total of thirty-six (36") inches from any part of the disconnect switch.
    b. For lighting and GFCI receptacles: 120V, 1 phase, 3 wires, 60 Hz terminating at the elevator controller location.
    c. Separate disconnect for cab lighting and wiring to cab. This disconnect shall be located close to the mainline disconnect.

d. Separate service for sill heaters where required.

e. Cutouts in hoistway walls for fixtures.

1) Smoke and/or heat sensors in machine room, in the car, and above each hoistway entrance.

f. Closed circuit television camera (CCTV) in the elevator car.

g. Intrusion detectors on machine room doors.

h. Space in kiosk for elevator annunciator panels.

i. All embedded electrical conduit between elevator hoistway, machine room, and kiosk.

j. Pit Drainage means to prevent water from accumulating in the pit for outdoor and indoor elevators. If pumps are used, they shall have a backup power source. The pit floor shall be sloped toward the pit drainage/ sump pump.

k. Lock and Key Requirements: The Contractor shall coordinate with WMATA. The keys for all elevators except of Code requirements shall be keyed the same. Each station shall have a key and a master key shall be furnished, which will operate all elevator locks in the Metro System, including previously installed elevators.

l. The Contractor shall coordinate any alterations required to accommodate elevators with the Authority.

m. The Contractor shall attend appropriate safety training programs provided by WMATA at no extra cost.

G. As-Built Drawings: The Contractor is responsible to provide revised Contract Drawings to reflect the actual as built condition including all structural, architectural, electrical, mechanical, and plumbing connections to the elevators.

1.05 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS

A. Design Requirements

1. General

a. Elevators furnished under this Contract shall be of the heavy duty automatic, hydraulic-type with a direct-acting plunger.

b. All parts shall be built to standard dimensions, tolerances, and clearances so that similar machines and devices supplied under contract are completely interchangeable. Elevators shall be designed with provisions for thermal expansion and contraction of complete elevator assemblies and for any movement of the facility.

2. Fasteners

a. Fasteners shall be compatible with materials being fastened.

b. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers or toothed disks).

c. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.

d. The mechanical fastening used throughout the equipment on parts subject to wear and requiring replacement shall be key and seat, nut, screw, or other removable and replaceable type not requiring physical deformation or field positioning. The use of rivets or similar devices will not be acceptable as mechanical fastenings for such parts.

3. Doors of elevators shall be of the horizontal sliding type, single speed, and center-opening. The doors shall be arranged for low-speed electric power operation.

4. Capacity, Speed, Travel, and Platform Size

    a. All parts of the elevator equipment shall be of such design, size, and material as to satisfactorily function under all conditions of loading and operation within its rated load and speed. All shall have a proper factor of safety, maximum mechanical, and electrical efficiency, and a minimum wear on parts.

    b. Hydraulic elevators shall have sufficient capacity to lift the rated load at 150 feet per minute with a tolerance of plus or minus 8.0 percent.

    c. Provide means to adjust the inspection speed. be adjustable between 25 feet per minute to a maximum of 150 feet per minute.

    d. The rated load shall be exclusive of the weight of the complete car and shall be determined in accordance with ASME Code requirements for passenger-elevators required to carry freight, Class C3 (ASME A17.1 Section 2.16) or 4500 pounds, whichever is greater.

    e. The travel, location, terminal floors, number of stops and openings, and the overall car platform size shall be as shown on the Contract Drawings.

    f. The anticipated freight load (cart) will be approximately 4 feet-1 inch by 2 feet in the plan, supported on four 8-inch wheels with 2-inch wide treads spaced approximately 2 feet-4 inches center-to-center longitudinally and one foot five inches center-to-center transversely. The loaded cart will weigh approximately 1,260 pounds.

    g. The entrance of the cart into the elevator car will produce eccentric forces which, acting through the guide rails, will result in additional deflections and deformation on the hoistway. These deflections and deformations shall not exceed one-sixteenth (1/16”) inches and shall not be permanent.

    h. The top enclosure shall be reinforced to support two men and capable of sustaining, without damage or permanent deformation, a load of 300 hundred pounds on any area one foot square and 100 pounds applied at any point. An emergency exit shall be installed in the car top in conformance with the Code.

    i. In-ground (holed) hydraulic elevator travel shall not exceed thirty six (36’) feet.

    j. Emergency Doors in Blind Hoistways: Where an elevator is installed in a blind hoistway, an emergency door shall be installed in the blind portion of the hoistway at every third floor, but not more than thirty six (36’) feet from sill-to-sill.

B. Performance Requirements

1. The elevators shall be designed for continuous operation seven (7) days per week, twenty four (24) hours per day.

2. Elevators shall be designed to be capable of operating with full specified performance capability while exposed to the climatic and environmental conditions described in the following paragraphs. In addition, during installation and until the beginning of scheduled maintenance service, the elevators will be subject to more extreme environmental conditions. The elevator shall furnish the amount of protection necessary to prevent any damage to or deterioration of the elevators during this period.

    a. Elevators shall be designed to operate in dry bulb temperature range of -10^0F to 140^0F and operate while exposed to the natural elements of weather, including sunlight, rain, snow, slush, salt; and all conditions of relative humidity, de-icing chemicals, debris, airborne dust, and corrosive elements.

    b. The elevators shall have a special winter operation. The elevators shall be designed to operate in the event the outside temperature falls below a pre-established minimum value. The Elevator Contractor shall furnish and install the necessary timers and thermostats to accommodate the desired function.

3. The elevator shall stop smoothly without any jerking or shocking during inspection operation.

C. Sound Level

1. No elevator car or elevator power unit shall generate noise in excess of NC45 sound level. Measurement of noise shall be made at a point three (3') feet from the hoistway, machine room entrances, and ventilation openings, either free running or under load. For multiple elevator installation, the noise measurements shall be made with only one (1) elevator unit in operation, but with the entire installation complete and in operating condition. An ambient level is not to exceed forty-nine (49) decibels shall be maintained prior to units being turned on.

D. Hoistway Movement

1. Elevators shall be designed to sustain the load and operate with the following lateral movements of the hoistway structures.
2. In any individual glazed area: 1/4 inch.
3. In total height of hoistway structure:
   a. Aerial and surface structures: 5/8 inch
   b. Underground structures: ½ inch
4. The elevator assembly shall be designed in a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.

E. Reliability

1. Each elevator shall be capable of operating at full load under any of the normal modes of operation at a level of availability of not less than ninety eight (98%) percent over a period of 365 days.
2. Availability (*A*) is defined as the portion of normal operational time during which the equipment is available for use. Or

$$A = \frac{MTBF}{MTBF + MTTR}$$

Where:

MTBF = Mean time between failure in days

= Operating time, *t* (in days) /Number of failures in time *t*

MTTR = The average time in days required to restore an elevator to operation after a report of a failure.

F. Seismic Loads

1. In accordance with Building Code, all structures shall be designed to resist the effects of earthquake motions.
2. The elevator shall be designed to comply with the seismic zone 2 requirements of ASME A17.1.

G. Closed Circuit Television (CCTV)

1. Make provision for and provide a Closed-Circuit Television (CCTV) camera, in the elevator car(s) with the ability to monitor the CCTV from the Kiosk annunciator panel. Submit drawings for approval before fabrication.
2. Provide electrical connections, through shielded traveling cables, between the camera and the communications terminal block in the machine room or pit.

H. Workmanship

1. Joints shall be welded their full length and dressed smooth and flush on exposed surfaces. Spot welding shall be used where practicable in preference to screw or rivet fasteners.

2. Sheet metal materials shall be accurately rolled and leveled, and have smooth finish and uniform color. Joints shall be formed to a tight fit, with abutting edges flush, and shall be securely welded or riveted together in such a manner as to give strength equivalent to the solid sheet. Riveted construction shall have heavy reinforcement on the back. No rivets shall show on exposed surfaces. Welds shall be solid and dressed flush, and holes for screws or bolts shall be drilled and countersunk.

3. Wrought work shall have joints milled to a tight even fit and, where possible, shall be made without screws. Square turns and comers shall be sharp. Curves and loops shall be true and without visible joints. Abutting members shall be welded, riveted or both. Similar bars shall be halved at intersections and wide bars shall be punched for the small bars to pass through.

4. The finished work shall be strong, rigid, and neat, and painted in appearance. Plane surfaces shall be smooth and free from warp or buckle. Molded members shall be clean-cut, straight, and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed from the face side of the material.

I. Corrosion Protection

1. The Contractor shall design the elevator assembly in such a manner as to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.

1.06 SUBMITTALS

A. Submit the following for approval in accordance with the Contract Documents and with the additional requirements as specified.

1. Product Data

a. The summation of product information shall be submitted, in tabular form, of all parts incorporated in the entire group of elevators supplied under this Contract. Hard copies and electronic copies on the Flash Drives shall be submitted.

b. Manufacturer's design data, material specifications, drawings, installation, and maintenance instructions including preventive, predictive, and general maintenance, and other data pertinent to the components used in the elevator systems, including, but not limited to, detailed repair data for all components, including disassembly, inspection/gauging/torque requirements, reassembly, testing and other related information. Submittals shall cover all mechanical components, operating panels, indicators, and electronic equipment to control and monitor elevator control functions. Exploded view drawings shall be included to facilitate repair and maintenance functions.

c. Lubricants, sealers, paints, and any other potentially hazardous substances are subject to review and approval by the Authority. The Contractor shall submit the necessary Safety Data Sheets.

2. The following information shall be provided:

a. Nomenclature of part.

b. Elevator Contractor's part number.

c. Nomenclature of next higher assembly in which used.

d. Manufacturer and part number.

e. Model number(s) of elevator(s) on which used.

f. Total quantity in entire group of elevators.

g. Current unit price to the Authority.

h. Recommended Spare Parts List showing parts with prices for each part. The parts listing shall be provided on or before 90 days prior to scheduled completion.

i. Loads on supporting members, reaction points, and deflections under varying loads.

2) Loads imposed on the structure shall be coordinated with the Authority and not exceed agreed limits. This requirement shall be verified, documented, and stamped by a registered Professional Engineer Supporting calculations shall be provided for record file.

3. Shop Drawings

a. The Contractor is to provide detailed drawings showing the dimensions and tolerance, specification that may include the material specification, hardness or electrical rating for each component that is being used. In regards to assemblies, they must provide a top-level drawing with BOM and quantities with detailed material specifications and drawings with dimensional tolerances. The Contractor is also to provide as-built CAD models of all elevator components.

b. The name of the manufacturer and type or style designation shall be listed on the each page of the equipment shop drawings. Drawings submitted shall include, but not be limited to, the following.

c. Fully dimensioned layout in plan and elevation, showing the arrangement of equipment and all pertinent details of each specified elevator unit, including as appropriate.

1) All equipment located in machine rooms.

2) Location of circuit breaker, switchboard panel (or disconnect switch), light switch, and feeder extension points in the machine room. These electrical components shall not be blocked by anything.

3) Location in hoistway of outlets for connection of traveling cables for car light, fire detectors, communication, and control system.

4) Car, hydraulic cylinder and plunger, supporting beams, guide rails, buffers, and other components located in the hoistways.

5) Maximum guide rail bracket spacing. Guide rail brackets shall be provided at every horizontal structural member and shall be of sufficient strength to meet the ASME Code.

6) Reactions at points of supports.

7) Weight of principal parts.

8) Top and bottom clearance and over-travel of car.

9) Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.

10) Refuge space on top of car and pit.

11) Cab design, dimensions, and layout.

12) Color/material schedule and selection chart for cab and entrance features.

13) Hoistway Ventilation: Thermostatically-Controlled, positive mechanical ventilation system.

14) Hydraulic Jack Details

15) Machine/Pump Room area, pit and hoistway layout.

16) Hydraulic piping layout indicating layout, type, size, and schedule of piping from machine room to elevator pit(s) indicating orientation of valve(s), and location of shut-off valve(s), and shall include calculations of working pressures.

d. Drawings of the hoistway entrances and doors showing their method of operation, details of construction, and fastenings to the structural members of the station structure.

e. Drawings of the car for each design specified, showing dimensions, details of construction, fastenings to platform, car-lighting, ventilation, air conditioning (if applicable), communication, and location of equipment.

f. Cuts (or drawings) showing details of all signal and operating devices, identifying graphics, and detailed design with diagram and schematic of kiosk annunciator panel.

g. Hydraulic drive:

   1) Cylinders and plunger.

   2) Power unit, including volume, rate of flow, working pressure, rpm of pump and horsepower, voltage, frequency, service factor, and rpm of the motor.

   3) Piping, fittings, and couplings.

   4) Valves.

   5) Storage tank.

   6) Muffler.

   7) Hydraulic Jack Detailed Drawings.

   8) Fluid flow diagram showing all valves, operating devices, and controls.

   9) Complete assembly detail of machine/pump, hydraulic tank mounting, with all load calculations.

h. Elevator controller, including manufacturer's technical data and catalog cuts, interface hardware, and software requirements.

i. Power door operator.

j. Door interlocks and electrical contacts including test reports showing that hoistway door interlocks, car door contacts, and car top emergency contacts meet the requirements of the ASME Code and certification by the NIST or other approved laboratory.

k. Car ventilation fan.

l. Car Air Conditioning (if applicable).

m. Car lighting.

n. Cabling.

o. Buffer, including stroke, and certified maximum striking speed for car.

p. Communication and intrusion system design details covering electrical, mechanical, and architectural aspects.

q. Design and architectural details, including light ray unit locations, of the electrical protective device for car doors.

r. Where the use of adjoining dissimilar metals is required, descriptions of protective measures to be employed to avoid corrosive damage.

s. Certification from independent testing laboratory that glazing gaskets meet the specified requirements.

t. Hall and car fixtures at each landing including the Car Operating Panel (COP).

u. Interface wiring diagrams with other systems showing terminal board location and identification.

v. Expected heat dissipation of elevator equipment in machine room and control areas (i.e. BTU’s/hr.) based on 240 round cycles per hour.

w. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.

x. Complete assembly detail of machine/pump, hydraulic tank mounting, with all load calculations.

y. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority. The Elevator Contractor shall submit the necessary Safety Data Sheets.

4. Samples

a. Three of each of the following samples shall be submitted for approval:

1) Steel cladding: Baked-enamel finish, six inches square. The sample shall show the rust-proofed surface of the base metal on one side and the prime and finish coats (stepped) of enamel on the other side. Although both sides of actual panels are to be enameled as specified.

2) Sheet metal: Six (6") inches square of thickness and finish specified.

3) Stainless steel cladding: Twelve (12") inches square of thickness and finish specified.

4) Glass: Twelve (12") inches square.

5) Floor covering: Twelve (12") inches square in the color and finish to be supplied.

6) Neoprene gasket: Each type.

7) Landing selector button mounted in cover plate with identity marking alongside button.

8) Signs: One of each type.

9) Ceiling material.

5. Certification

a. Certificates of inspection and acceptance issued by Jurisdictional Authority.

b. The Acceptance Inspection (Specifications and Code) by the Office of the Elevator and Escalator (ELES) shall take place prior to the Final Acceptance Inspection by the Jurisdictional Authority, and the elevators and associated equipment shall be free of defective material, imperfect work, and faulty operation.

c. All defective work identified by ELES representatives shall be repaired or replaced at no additional cost to the Authority prior to the Final Acceptance Inspection by the Jurisdictional Authority.

6. Operation and Maintenance Manuals

a. Six (6) sets and electronic copy of the approved manuals, elevator installation, operation instuctions, troubleshooting techniues and related equipment drawings and software (all publication must be in English). Two copies shall be delivered to the WMATA/ELES Engineer representative of the Authority at least 60 days prior to the final acceptance. Each binder shall has the Binder Cover and Spine Insert which contain the Station Name and Unit ID.

1) Submit an electronic copy of the Manual for the review and approval, after installation and at least 90 days prior to the final acceptance. The iinformation shall be saved/presented as follows:

2) Graphic images in ".dwg," AutoCAD, and ".pdf" formats. All revisions shall be made by using computer software. Hand-written changes are not acceptable.

3) Text in Microsoft Word .doc, ".pdf" or approved equal format.

b. The manuals shall include the following:

1) Complete operation and maintance Instructions of the elevator equipment including complete illustrated, exploded views of all assemblies, and a complete illustrated, exploded view for identification all system parts.

2) Complete nomenclature of replaceable parts, part numbers, current cost, and warehouse location. If product source is another vendor, Contractor shall include name and address of other vendor.

3) Furnish a summation, in tabular form, of all parts incorporated in the elevators supplied under the Contract. Include, but not be limited, to the following:

   a) Nomenclature of part.

   b) Contractor's part number.

   c) Nomenclature of next higher assembly in which used.

   d) Manufacturer and part number.

   e) Model number of elevator on which used.

   f) Total quantity.

   g) Current unit price to the Authority.

   h) Serial numbers of all serialized assemblies, subassemblies, motors, and other major components supplied, and installed.

4) Control and schematic electrical wiring diagrams of controller, including wiring of safety devices.

   a) Wiring Diagrams shall be full size (11x17”), ladder-type, complete "as-built" wiring and single line diagrams showing the electrical connections, functions, and sequence of operation of apparatus connected with each elevator, using standard symbols or proprietary symbols defined on the diagram. Both Diagrams in the machine room and in the hoistway, shall be furnished in duplicate for each elevator.

   b) Wiring diagrams shall incorporate the wiring identification labeling to identify the controller and field wiring used for each circuit. The PLC address shall be represented for all inputs and outputs. The name shall be accompanied with the PLC address. Wiring diagrams shall have sheets numbered with an indication of the total number of sheets in the diagram set. Each page should include the unit number where the diagram belongs to.

   c) After approval, a copy of each print (11x17) shall be laminated and mounted with non-metallic holder in each elevator machine room. A hard copy set of wiring diagrams for each elevator shall be delivered to ELES Engineering Office.

   d) Coded diagrams are not acceptable.

5) Complete detailed drawings and wiring diagrams of the elevator system.

6) Lubricants, sealers, paints, and any other potentially hazardous substances are subject to review and approval by the Authority.

   a) Provide SDS for all the lubricants/chemicals.

   b) Provide the manufacturer part number.

   c) Provide the name of the manufacturer.

7) Detailed lubrication and cleaning schedule.

8) Procedures for adjusting all elevator components.

9) Complete set of contract software including operating control software.

10) Detailed, record, and as-built layout drawings.

11) The entire manual, all software upgrades, and service tools for elevators shall be provided in an electronic format on Flash Drive that is acceptable to the WMATA Engineering and Maintenance Department.

12) All hard copy publications shall be in loose-leaf form, on 30-pound paper with punch holes reinforced with plastic, cloth, or metallic material.

    a) The O&M manual shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed. The fonts should be in standard format.

    b) All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.

13) Each elevator shall be treated as a whole and not as a grouping of disassociated parts. The material in the Wiring Diagram Manual shall be organized and indexed by the elevator classifications included in this Specification. All manual sections shall be sub-divided, to the extent required by the subject matter, and shall include, but not necessarily limited to, the following topics:

    a) General system or sub-system description and operation.

    b) Sequence of operation.

    c) Replacement and step-by-step adjustment procedure for all components and systems.

    d) Block diagrams.

    e) Functional schematics.

    f) Functional as-built wiring diagrams.

    g) Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.

    h) Component location and description.

    i) Inspection and maintenance standards including wear limits, settings, and tolerances.

    j) Installation and removal sequence.

    k) Test and evaluation procedures.

    l) Spare Parts Lists and special tools.

14) The Contractor shall provide all information: manuals, drawings, design changes, modifications, techniques, procedures, and any other documents related to maintenance, safety, operations which relate to any part, component, system, subsystem, or material, and applicable to the elevator equipment. All operating, programming, control software, and licensing keys (if applicable) to the PLC control system for the installation.

15) All of the above referenced shall be provided as it pertains to the original installation and for a period of ten (10) years after final acceptance of the elevator. During a ten (10) year period, in case of any items are obsolete or no longer available from the manufacturer, the Elevator Contractor shall provide the alternative products.

7. Elevator Maintenance Control Program (MCP)

    a. Provide a separate Maintenance Control Program (MCP) for each unit as required by A17.1 Code.

        1) Submit an electronic copy of the MCP to ELES Engineering for the review and approval.

        2) Provide one (1) copy of the the approved MCP at each elevator machine room.

3) Three (3) sets of hard copies and electronic version of the approved MCP shall be submitted to the WMATA/ELES Engineer representative.

4) The MCP shall include, but not be limited to, the Code required maintenance tasks, maintenance procedures, examination, and tests procedures.

5) The MCP shall specify examinations, tests, cleaning, lubrication, and adjustments to applicable components at regular intervals.

6) The MCP shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed.

7) The instructions shall be permanently legible with characters a minimum of 0.125 in. (3 mm) in height.

8) All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.

9) Each unit shall be treated as a whole and not as a grouping of disassociated parts. The material in the MCP shall be organized and indexed by the elevator classifications. Each binder shall have the Binder Cover and Spine Insert which includes the Station Name and Unit ID.

8. Field Quality Control

a. Provide a quality control program for approval by the Authority.

1.07 OPERATION AND MAINTENANCE TRAINING

A. Training

1. The Contractor shall develop and provide operation, troubleshooting, and maintenance training in accordance with the General Requirements.

a. Three (3) days of classroom training plus two (2) days of hands-on training in the field shall be provided for ten (10) students per class. Six (6) training sessions for a total of sixty (60) students is required.

b. Time and place of training will be determined by the Authority, but must be completed no later than thirty (30) days prior to the Final Completion.

c. Training shall be organized to make optimum use of the required maintenance and operation manuals including training for replacement of all parts contained in the Parts Inventory List.

d. At the completion of the first training session, a narrated and properly edited training video shall be submitted for the Authority on DVD or flash drive. The video shall be taken by the professional camera operator with quality image and sound track and will be used for the future trainings. The video shall cover operation of the elevator, function of the devices, maintenance, adjustment procedures and troubleshooting. The following items shall be included as minimum requirements:

1) Step-by-step adjustment procedure on the following:

a) Door operators, DCL, DOL, full door opening, and so on.

b) Valve adjustment.

c) Car Leveling and adjustment of leveling sensors and vans.

d) Door: Door interlock, proper pressure, and restrictors.

e) Pump motor: Belt tension and alignment.

2) General overview of major items:
    a) Packing
    b) Pistons
    c) Shut off valves
    d) Controllers
    e) Controller displays
    f) Hydraulic pumps
    g) Hydraulic tanks
    h) Door sills
    i) Guide rails
3) Daily operation and sequence of operation.
4) Replacement and Installation of components:
    a) Hydraulic packing
    b) Door photo eye
    c) Hydraulic valve
    d) Door clutch
    e) Door pickup rollers
5) Proper guide roller adjustment
6) Verification of safety circuit
7) Maintenance procedure and Frequency of maintenance
8) Proper access of pit and top of car for inspection
9) Proper test of fire service operation
10) Proper lubrication of components
11) Troubleshooting techniques
12) How to use proper communication device, machine room, car top, and the kiosk.

e. Provide one (1) additional copy of all required submittals to the ELES Engineer for Authority use.

f. Provide two (2) copies, in DVD format, of training materials along with visuals and handouts to the Engineer for the Authority use.
    1) Video shall be narrative.
    2) Video shall be separated by major components Sections.
    3) Equipment Identification shall be as a part of the section title.

g. A separate training manual shall be submitted for approval prior the scheduling of the training. The O&M manual shall not be used as a training manual.

2. Scope of Work

a. All training, as described below, shall take place prior to Final Acceptance of equipment or materials by the Authority. Operations and maintenance training may take place as a combined class by agreement of the Office of Elevators and Escalators (ELES). The minimum number of ELES employees to be trained will be no fewer than sixty (60) total with a maximum of ten (10) per class. Those persons will be identified by WMATA. The Contractor shall video tape all

training sessions and provide WMATA/ELES with an edited copy of the recording as stated above.

b. Operations training shall be tailored specifically to the furnished and installed equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.

c. Maintenance Training shall be tailored specifically to the furnished and installed equipment and designed to develop the knowledge and skills required to maintain all item(s) delivered.

d. Maintenance training shall be subdivided into two major levels as follows:

1) System Level Maintenance Training, and covering:

a) Theory of operation of the system and its major components.

b) System configuration.

c) Preventative maintenance, consisting of written procedures, and schedules for the periodic maintenance of all equipment.

d) Written and validated inspection procedures, and a system-level trouble-shooting guide (to the lowest field-replaceable unit).

2) Shop Level Maintenance Training and covering

a) Detailed theory of operation to module, board, and/or device level.

b) Component level troubleshooting, component replacement, and adjustment.

c) Testing and alignment procedures of repaired units.

3. Deliverables

a. The following course materials shall be delivered by the Contractor, according to the following specifications:

1) An Instructor's Guide containing all the information and direction necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separable blocks (or modules) which may be taught as a unit. The Instructor's Guide shall contain, at a minimum:

a) Discussion of student prerequisites (if any).

b) Program overview.

c) A statement of overall program goals.

d) Lesson plans (a session-by-session outline containing the following):

I. Student learning objectives, stated in measurable terms.

II. Overview of each lesson.

2) A Student Manual including all materials for the student to interact in the learning situation. It shall contain, at a minimum:

a) Program overview and introduction.

b) Statement of overall program goals.

c) Learning objectives, stated in measurable terms that specifically describe desired behaviors or knowledge to be gained.

d) A fully-developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide.

e) Illustrations, charts, photos, and other graphics of actual system components as needed to enhance content presentation.

f) The training manuals shall be prepared and submitted for approval to WMATA/ELES prior to training. The training manuals shall include procedures for adjustment and replacement of all electrical and mechanical components, and a troubleshooting guide.

3) Audio-visual Aids consisting of a narrated video of not less than ninety (90) minutes duration to include, but not limited to, the following:

a) General overview of major features.

b) Daily operations.

c) Maintenance procedures such as lubrication, adjustments, critical measurements, etc.

d) Frequency of maintenance procedures.

e) Parts replacement such as safety devices, lighting, etc.

f) Verification of safety circuits, methods of accessing and preserving computerized functional data if required.

g) Step-by-step adjustment procedures and installation of components.

h) Handouts, transparencies, and/or slides as necessary to ensure clear and comprehensive presentations.

i) The training video shall be taken from actual equipment installed under this contract by the professional camera operator.

4. Supplemental Materials consisting of a functional mock-up or a functional representation is required of any equipment that requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or an Authority approved substitute. All mock-ups shall become the property of the Authority for eventual turn over to WMATA/ELES.

5. The final copies shall be delivered to the Authority as follows:

a. One complete set of training materials that is completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies such that further copies can be made from them with no noticeable decrease in copy quality.

b. Five copies of all student and instructor materials, to be used for archival purposes, in the WMATA ELES Technical Library.

c. A set of complete student materials, including training manuals for each participant enrolled in training classes. The O&M manual, training manuals, and special tools shall be approved by the Engineer and delivered to the Authority for eventual turn over to WMATA ELES.

d. The Contractor shall video record all training sessions and provide WMATA/ELES with edited DVD copy of the recording to be used as training guide for other WMATA ELES employees.

6. The following specifications shall be met in instructional delivery:

a. Instructor Qualifications: A description of instructor qualifications, a resume, curriculum vitae, or other description of instruction qualifications must be submitted at least sixty (60) days prior to the presentation of training. The description shall document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instructional. The ELES Engineering Office will review and approve the Instructor candidacy.

b. Course length: The length of the course shall be five (5) working days with three (3) days in the classroom and two (2) days hands-on training.

c. Student qualifications: For the purposes of course development and presentation, vendors shall assume all WMATA students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.

d. Testing: Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the Authority and Contractor. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/ mechanical skills.

7. Flash Drives

a. Each flash drive shall include electronic copies of:

1) Operating Manual.

2) Maintenance Manual.

3) Annotated .dwg and .pdf wiring diagram.

4) Parts listing with manufacturer's part number and corresponding WMATA part number.

5) Annotated and original Logix (ACD) file.

6) Original display program for panel.

7) Maintenance Control Program (MCP).

8) Each flash drive shall provide operating, trouble-shooting and maintenance instructions, parts listing; recommended parts inventory listing, purchase source listing for major and critical components, emergency instructions, and similar information. Maintenance instructions shall include recommended lubrication frequency, and periodic maintenance requirements and schedules. Parts list and purchase source listing shall include electrical and control equipment. Manuals shall also include approved drawings and catalog cuts, folded if necessary. Manuals shall include information on maintenance/replacement cycles and design life expectations.

1.08 SPARE PARTS AND SERVICE FACILITY

A. Metal Cabinet

1. A metal cabinet of suitable size shall be provided in each machine room for the storage of special tools and necessary spare parts. The cabinet shall be mounted on legs or a pedestal, a minimum of four (4") inches off the floor. A Mobile Tool Storage Cabinet with wheels is not allowed.

B. Spare Parts

1. At the expiration of the warranty requirements of the General Provisions, the Contractor is responsible to provide a source for spare parts and service facility in the United States which can be obtained for an additional five years. If product source is another vendor, Contractor shall include name and address of other vendor.

2. The Contractor shall propose and provide a spare parts inventory to be approved by the Engineer and provided to the Authority not less than ninety (90) days prior to scheduled completion, equal in value to seven (7%) percent of the cost of each elevator.

3. This provision requires the furnishing of a Recommended Spare Parts and Special Tools List based on manufacturer's recommendations, defines criteria to be used by the Contractor in developing spare parts recommendations. The List also defines the manner of identifying spare parts, the labeling, and identification of spare parts upon delivery; and the timing of delivery of spare parts.

4. Elevator Parts List grouped by system and subsystem for stocking identification and the List shall contain the following information for each item listed:
    a. Component name and Part number(s)
    b. Manufacturer's name
    c. Model number(s)
    d. A blank column for WMATA's part number
    e. Manufacturer's recommended quantity
    f. Anticipated annual usage
    g. Unit price
    h. Special storage and handling requirements
5. The manufacturer's recommended quantities shall be based upon the following reliability, usage, and lead time considerations:
    a. Wear: Components which may be expected to require replacement under normal maintenance schedule and operations, such as mechanical parts subject to continuous operation within projected Mean Time Between Failure (MTBF) levels.
    b. Consumables or Expendables: Components which are consumed, used up, destroyed, or upon failure, are otherwise made usable for their intended purpose and are economically unrecoverable except for inherent scrap value.
    c. Recoverable or Repairable: Components which, upon failure, are capable of being repaired or remanufactured to a serviceable, operational condition, and maintained available for use within their initial intended purpose.
    d. Long Lead: Components that is not available from commercial distributors or within forty-eight (48) hours from the manufacturers such as specifically made or selected components.
6. Cross referencing: Where replacement components are common to more than one system or subsystem, include a cross reference and indexing system in the replacement components list:
7. Non-Unique parts: In all components lists, items that are not unique to the system and have been manufactured by others shall be identified by the manufacturer's name and part number.
8. WMATA will provide the Elevator Contractor with shipping instructions with WMATA part numbers for each item the Elevator Contractor is required to furnish.
9. The parts shall be shipped to the locations as directed by the Authority. Shipping documents shall identify the Contract number, manufacturer's part number, quantity, unit price and WMATA part number.
10. Spare parts shall be properly packaged or crated so as to prevent damage during shipment and long-term storage. An individual packing slip shall be included inside the package or crate.
11. Spare parts shall be the same in all respects as their counterparts furnished as a part of the assembled equipment to be delivered.
12. Parts furnished in accordance with this provision are WMATA spares, separate and distinct from any Contractor obligation to replace parts, components or assemblies under any warranty provision.
13. Parts lists contained in Operations and Maintenance Manuals provided under the Contract shall include assigned WMATA part numbers.
14. A Manufacturer’s Recommended Spare Parts List shall be provided. Parts to be provided shall be based on the criteria described herein and require Authority approval and shall be provided prior to Final Acceptance.

15. Any Special Tool(s) used including, but not limited to, troubleshooting, maintaining the elevator, software and/or hardware shall be provided as part of the spare parts to the Authority. Any tools provided shall be the same as those issued to the Adjuster and equivalent members of the sub-Contractor's staff.

1.09 SPECIAL TOOLS

A. A complete set of special tools and instruments necessary for troubleshooting, maintenance, repair, and making all adjustments on every part of the elevator installation, including software and hardware shall be furnished for each elevator and delivered to the Engineer as part of the spare parts inventory. Tools that are designed specifically for tasks associated with elevator inspection, maintenance, and repair or that are required for these tasks, and are not readily available through normal purchasing channels are defined as "Special Tools."

B. Any "Special Tool/ equipment" that is required to troubleshoot, maintain, adjust, and test the system shall remain operational for the life of the equipment.

1. Provide all special tools and equipment necessary for making all system adjustments to the signal and speed controller and door equipment. A programming unit, approved by equipment manufacturer (OEM) such as a new laptop with minimum 4GB memory, 15-inch display and DVD drive, with all software packages required to setup and program all equipment in the elevator system shall be provided, one per station or location. Software shall be provided for the display unit, Device Net, hoist motor drive, if applicable, and any other programmable devices, as well as for the controller PLC. Any hardware or software required for configuring, programming, and or communicating to controller or any parts of the elevator shall be submitted to ELES engineering. Using the provided laptop, the Contractor shall demonstrate loading, downloading (programming) any and all software that is required for the elevator for all operating needs. This includes display, PLC, and any I/O controls. All special tools shall be new and to be provide with casing. No special tools with decaying circuits or clocks are permitted. All application programs included in this elevator shall be the property of WMATA and shall not be considered proprietary to the OEM.

C. Keys: Provide ten (10) sets of keys per elevator to operate all keyed switches and locks prior to completion of the first unit.

1.10 PROJECT SITE CONDITIONS

A. The project site premises shall be visited by the Contractor to be thoroughly familiarized with all details of work and working conditions. All dimensions shall be verified in the field and by comparison with the station structural and finish (information) drawings. The Authority shall be informed of any discrepancy before ordering equipment or performing work. Coordination and proper relation of this work to the structure and to the work of all trades shall be performed.

B. The Elevator Installer shall install all elevator wiring in the embedded conduit provided by other trades including that to the kiosk. Other trades will bring wiring for their services to either the elevator machine room or the elevator pit, terminated on a terminal block. The Elevator Installer shall extend wires from the terminal blocks to the appropriate location or device within the elevator enclosure or hoistway. Some of these circuits shall require shielded wires or isolated circuits.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Ship equipment and accessories securely packaged and labeled for safe handling and to prevent damage.

B. Protect equipment exposed finishes during transportation storage and erection against damage and stains.

C. Deliver components with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

D. Store in in clean, dry, and secure areas and protect them from weather and damage.

1.12 WARRANTY

A. Warranty: A two (2) year warranty of construction shall start at Final Contract completion.

B. The Original Equipment Manufacturer (OEM) shall warrant in writing that all equipment manufactured and installed under this specification, for a period of twenty four (24) months from the date of Final Acceptance by the Authority, be free of defects in design, materials, and workmanship, under normal use and service. Defective work shall be repaired or replaced at no additional cost to the Owner.

C. The warranty shall include materials and labor necessary to correct defects.

D. The warranty does not begin until all of the following requirements have been met.

1. The Operations and Maintenance Manuals are accepted by WMATA.
2. The required training has been completed to the satisfaction of WMATA.
3. All field tests have been successfully completed.
4. The acceptance testing has been successfully completed.
5. The elevators are in service for passenger/public use.
6. The State and local jurisdictions have inspected the elevators and issued the respective Certificates of Operation.
7. All spare parts have been delivered and received by WMATA.
8. Any discrepancy identified by the ELES representative shall be repaired or replaced by the Contractor at no additional cost to the Authority.

1.13 AUTHORITY COORDINATION

A. The elevators shall not be in service for passenger/public use until all of the following requirements have been met.

1. The Operations and Maintenance Manuals have been approved and received by WMATA.
2. The Training and Student Manuals as well as video record of all training sessions have been approved and received by WMATA.
3. The required training has been completed in accordance with this specification.
4. All field tests have been successfully completed.
5. The acceptance testing has been successfully completed.
6. All spare parts have been delivered and received by WMATA.
7. All Special Tools/Equipment and Software have been delivered and received by WMATA.
8. All discrepancies identified by the WMATA's CEI (Certified Elevator Inspector) representative shall be completed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The major elevator components shall be the products of one of the three manufacturers of established reputation, except they may be the products, either wholly or in part, of another manufacturer of established reputation provided such items are capably engineered and produced under coordinated specifications to ensure a high grade, safe, and smooth operating system.

B. The major components to be furnished for this project shall be of a make or makes that have performed satisfactorily together under conditions of normal use for not less than five (5) years in at least two other elevator installations of equal or greater capacity and speed.

2.02 MATERIALS

A. Stainless Steel

1. Shapes and Bars:
    a. ASTM A276, Type 304 or 301 for non-exposed components, and Type 316, all finish panels, and exposed components.
2. Plate, Sheet, and Strip
    a. Over 1/8 inch, ASTM A264 with ASTM A240, Type 316 on ASTM A36 base.
    b. Under 1/8 inch, ASTM A167, Type 304, Type 316, for all finish panels and exposed components.
3. Stainless steel finish shall be NAAMM NO.4 with vertical grain.
4. Stainless steel screws, bolts, and nuts shall be used for fastening and shall be AISI Alloy 303.

B. Steel Sheet and Steel Fabrications

1. Steel sheet for top enclosure shall be minimum 12-gauge.
2. Steel sheet for hoistway door frame shall be minimum 12-gauge.
3. Steel sheet for corrugated floor decking shall be minimum 10-gauge.
4. Steel sheet for the subfloor shall be minimum 3/8-inch thick.
5. Bronze (or anodized aluminum) sheet for cladding shall be a minimum of 16 gauge. Bronze (or anodized aluminum) sheet for top enclosure shall be minimum of 12-gauge. Bronze (or anodized aluminum) sheet for hoistway door frame shall be minimum of 12-gauge.
6. Galvanized steel material shall comply with ASTM A123, ASTM A153, and ASTM A653 (G90 Coating) as applicable. All steel sheet and steel fabrications, except lubricated machinery parts, which are not shown or specified to have other applied finishes, shall be galvanized.

C. Steel Finishes

1. Provide protection for all metal parts, fittings, and accessories by painting or galvanizing, except for stainless steel or anodized aluminum.
2. Where visible to the public, steel surfaces shall have a baked enamel finish unless otherwise shown.
    a. The color shall meet the requirements as shown in the finish schedule on the contract drawings.

b. Baked enamel finish shall consist of a thorough hot chemical cleaning process, a six-step zinc-phosphate process, two (2) prime coats, and one (1) finish coat of sprayed acrylic enamel (1.25 mils thickness minimum), baked at 350ºF for a minimum of 30 minutes.

3. Fasteners

a. Fasteners securing removable sheet metal materials shall be operable with the aid of simple tools and concealed wherever possible. When the framework to which the metal is fastened is less than 1/4-inch thick, steel backup plate's 1/4-inch thick shall be added with tapped holes and clearance holes where necessary. Exposed fasteners shall match the color and finish of the material being fastened, and shall be tamper-proof flat-head machine screws of a captive screw fastener design.

2.03 EQUIPMENT AND COMPONENTS

A. The hydraulic elevator drive shall be of the oil-electric type with direct-acting plunger, power unit, oil storage tank, and control equipment. The power unit, storage tank, and associated control equipment shall be mounted in the machine room.

1. Cylinder and Plunger

a. The cylinder and plunger unit shall be designed and constructed in accordance with the applicable requirements of the ASME Code and other applicable codes. It shall be of sufficient size to lift the gross load to the height specified and shall be factory-tested at a pressure of 400 psi. Gray cast iron or other brittle materials shall not be used in the construction of the cylinder and plunger unit. The cylinder shall be coated on the outside to prevent rust and corrosion. The bottom of the cylinder shall be closed and the top provided with an internal guide bearing and a cylinder head. The cylinder head shall be equipped with an adjustable packing gland designed to effectively prevent leakage of oil. A scavenger pump shall be provided to return oil to the system. It shall be located so as not to obstruct the path between the pit entrance and the cylinder.

b. The packing gland shall be constructed to permit easy repacking.

c. The cylinder shall be provided with a means to release air or other gas and shall have a drip ring below the packing gland to collect all oil leakage.

d. The cylinder shall be secured to a support, provided by the Contractor, which will transfer and distribute the load to the floor of the hoistway pit.

e. Plunger of built-up construction shall be secured to the car platform by means of a suitable platen.

f. Plunger shall be designed to prevent its leaving the cylinder.

g. The cylinder shall be isolated from soil, ground water, pit channel, building structure, and other sources of possible corrosive or galvanic damage by being installed in a PVC casing with the area between the cylinder and the casing left empty and free of water and oil.

h. The cylinder shall be coated with corrosion-rust resistant primer and painted with a dark gray industrial epoxy or other approved paint.

i. The top of the cylinder shall be jointed to the PVC liner by a Victaulic coupling forming a sealed unit.

2. Well Hole and Casing

    a. Well Hole and Well Hole Casing

        1) The well hole shall be plumb enough to provide a plumb installation of the PVC inner casing and pressure cylinder.

        2) The well-hole outer casing shall be installed to retain the well hole for installation of the PVC casing and pressure cylinder.

        3) The well-hole casing shall be 3/8” thick welded steel pipe.

3. PVC Casing

    a. The PVC casing inside the well casing shall be 1/2” thick minimum, water tight and free of any liquid or debris after being installed plumb in the well hole.

    b. Exterior surface of casing shall be cleaned prior to application of solvent welding material to ensure watertight connections.

    c. The PVC casing shall be capped with PVC to prevent liquid and debris from getting in the area between the PVC casing and the cylinder.

    d. The PVC casing shall be capped at the bottom.

    e. Provide top of PVC with a PVC pipe coupling connecting with cylinder Victaulic coupling.

    f. A PVC pipe shall be installed in the PVC casing to allow installing hydraulic piping to the cylinder. The PVC casing shall be secured at its base relative to the outer casing. Gaps between the PVC and outer casing may be filled using clean, dry backfill or other approved material.

    g. An electronic monitoring device shall be installed to detect the presence of oil or water in the PVC casing. A “Liquid in Casing” alarm signal shall be provided to the elevator controller for display on the fault display and transmitting to the remote monitoring system.

    h. An evacuation tube with an evacuation port shall be provided between the PVC liner and the cylinder.

4. Cathodic Protection

    a. The cathodic protection shall be provided for cylinders and piping and shall be provided by dielectrically isolating the cylinder and piston from the car platen, pit support structure, and pressure piping.

    b. Gaskets and pads for dielectric insulation shall be neoprene or approved alternative. Insulating sleeves, washers, and oil line coupling shall be provided where specified or shown.

5. Power Unit

    a. The power unit shall consist of a screw-type or gear-type oil pump driven by an electric induction motor with oil control valves, combined in a self-contained unit fabricated of structural steel. Power unit drive motor is specified under Electrical Work (See Section H.15). Submersible units will not be accepted.

    b. The oil pump shall be especially designed and manufactured for hydraulic elevator service. It shall be designed for a steady discharge with minimum pulsation to give smooth and quiet operation. The pump shall be of proper size and shall deliver oil into the cylinder in sufficient quantity and pressure to lift the elevator car with specified load at specified speed. During downward trip of elevator, the oil shall be returned to the tank by gravity.

    c. Geared pumps, when used, shall be provided with accurately cut herringbone or helical gears. The gears shall operate under flooded suction in an accurately machined case with close clearances to assure maximum efficiency. An effective strainer shall be provided in the suction line to the pump. The power unit shall be equipped with a vibration isolation device suitable for

use with and approved by the power unit manufacturer. The vibration isolation shall effectively prevent the transmission of power unit vibration to the machine room structure.

6. Piping, Fittings, and Couplings

   a. Piping, fittings, and couplings shall be furnished and installed between the storage tank, pump, muffler, valves, and cylinder complete with necessary supports.

   b. All connections between the discharge side of the pump check valve, muffler, cylinder, and lowering valves shall be of rigid steel with screw, flanged, welded, or approved mechanical couplings.

   c. Pipe supports shall be provided within twelve (12") inches of every change of direction in piping.

      1) Supports shall not be more than ten (10') feet apart.

      2) Secure vertical runs properly with iron clamps at sufficiently close intervals to carry weight of pipe and contents and provide supports under pipe to floor.

      3) Furnish and install all piping from remote machine room to hoistway, including necessary supports and/or hangers.

   d. Size of pipe and couplings between cylinder and pumping unit shall be such that fluid pressure loss is limited to ten (10 lbs.) pounds.

   e. Mechanical couplings, when used, shall be of a self-centering type that provide for some degree of deflection, contraction, and expansion.

      1) Couplings that provide for partial or full separation of the two sections of piping being connected are acceptable, provided all other specified requirements are met.

      2) Couplings shall be rated for a pressure at least three (3) times the working pressure of the elevator and shall be so designed that failure of the flexible sealing element or gasket shall not permit the separation of the parts connected.

      3) Flexible sealing elements or gaskets shall be of a type and material suitable for use with the hydraulic fluid furnished.

   f. Where piping, fittings, and couplings supplied by the Contractor are contained within sleeves, conduit, trenches, troughs, or other passage means provided by others to allow for the connection of the power unit with the cylinder and plunger, the Contractor shall provide appropriate devices which shall effectively prevent the transmission of vibration to the surrounding structure.

   g. The Contractor shall install all piping, fittings, and couplings used to connect the power drive to the cylinder and plunger in such a way that these may be removed and replaced at a future date. When Victaulic is used, there shall be access for inspection and maintenance. Destruction of portions of these items in the process of removal is acceptable but efforts shall be made in the designs to minimize the necessity to destroy items.

7. Valves

   a. Valves shall be of the unitized manifold type with no more than four (4) solenoids and arranged so that all adjustments are individually adjustable without the need for sequential readjustment. Valve shall be designed to ensure that oil flow will be controlled in a positive and gradual manner, thereby ensuring smooth starts, operation, and stops of the elevator car.

   b. Valves shall be designed for quiet operation and shall be mounted above the storage tank in a manner that allows leakage to drain back to the tank.

   c. A safety check valve shall be provided which will function to hold the elevator car with rated load at any point when the pump stops or the maintained pressure drops below the minimum operating pressure required holding the car in place.

   d. A manually-operated lowering valve shall be provided, which shall permit the manual lowering of the elevator car in the event of a power failure. The location of the lowering valve and access to

it shall be described in white-stenciled lettering on the front panel of the pump unit. The lowering valve operating means shall be easily and readily accessible and unobstructed by the valve wiring, conduits, or other equipment. A tank shut-off valve shall be provided to permit isolating the oil in the tank during maintenance operations. The location and orientation of the valve shall allow for safe operation of the handle throughout its range of travel.

e. All additional pump relief valves and other auxiliary valves required by the ASME Code or necessary to provide smooth, safe and satisfactory operation of the elevator shall be furnished and installed.

f. Any relief valves having exposed pressure adjustment shall have their adjustment sealed after being set to the correct pressure.

g. Manual shut-off valves shall be provided in the hydraulic oil line in the elevator pit and in the elevator machine room. In any portion of its travel, the machine room shutoff valve handle shall not intrude in the walk space, work space, or obstruct access to other equipment.

8. Storage Tank

   a. The storage tank shall be constructed of steel and shall be provided with a steel cover, protected vent opening, overflow connection, and a valve drain connection. The tank shall act as a storage tank only. Suitable gauge glasses shall be provided if the top of the tank is over four (4') feet above the floor. An initial supply of oil sufficient for proper operation of the elevator shall be provided. The tank shall have a capacity equal to the volume of oil required to lift the elevator to the top terminal plus a reserve of not less than ten (10) gallons.

   b. The oil storage tank cover shall be arranged for easy unobstructed access. Clearance of 24 inches vertical and 18 inches horizontal from tank cover shall be maintained for ease of service.

   c. The permissible minimum liquid level shall be clearly indicated. The manufacturer's recommendation of type of oil to be used shall be included in the written instruction for the care, adjustment, and maintenance of the equipment. The flash point of oil used shall be not less than 400°F.

   d. Provide an oil filtering system that removes contaminants that can clog valves and settle in the bottom of the tank.

   e. Blowout-proof foil-hydraulic muffler of an approved make shall be furnished and installed in the oil line near the power unit to reduce noise to a minimum.

9. Oil Temperature Control

   a. Tank Heater: Hydraulic oil viscosity/temperature control shall be provided by the application of an internally mounted, thermostatically controlled, tank heater. The oil temperature shall be maintained at a maximum 110°F with the use of a 120 VAC powered tank heater. The unit shall be permanently mounted, integral with oil reservoir, and with a lighted switch/indicator to visually confirm unit is powered. The tank heater shall include the switch for disconnection of power during maintenance/repair operations. The unit shall be hard-wired to electrical source per ASME A17.1.

   b. Hydraulic Oil Cooler: Provide a thermostatically controlled hydraulic oil cooler to maintain hydraulic oil at the OEM's recommended optimum operating temperature. Hydraulic oil cooler shall be provided with the following:

      1) An electrical box for direct wiring to 115VAC, 30 Amp separate circuit.

      2) All fittings and hardware needed for adjacent-mount installation and remote wall mount installation.

10. Elevator Car Buffers: Heavy-duty spring buffers shall be provided, mounted on the supporting channel or block on the pit floor. The buffers shall comply with the requirements of the ASME Code. Buffer anchorage at pit floor shall be arranged to avoid damaging the waterproofing.

11. Car guides consist of a guide rail and guide-rollers. Guide rails for the elevator cars shall be of planed steel standard T-section. Guide rails shall be erected plumb and parallel with a maximum deviation of one-eighth (1/8") inches and shall be securely fastened to the bracket or other supports by approved heavy rail clamps.

    a. Car Roller Guides:

        1) The elevator car shall be provided with roller guides.

        2) Roller guides shall be spring-loaded and allow rail-to-rail and front-back adjustment of the rollers.

        3) Three or more rollers per guide shall be provided and have four (4") inches minimum sound-deadening wheels.

B. Operation

1. Operation shall be automatic. Automatic operation by means of car and landing buttons. Stops registered by momentary actuation of car buttons to be made irrespective of number of buttons actuated or of sequence in which buttons are actuated.
2. Operating panel in car containing bank of buttons numbered to correspond to landing served position indicators. EMERGENCY CALL button, keyed EMERGENCY STOP button, DOOR OPEN/DOOR CLOSE buttons, independent maintenance key switch, and key-operated light and fan switches, shall be provided with legends as specified. Identification shall be provided as specified for an emergency telephone. An emergency call button connected to bell that serves as emergency signal shall be provided. Panel finish shall be Stainless Steel.
3. Landing: Single push-button fixtures shall be provided at each terminal landing. Button fixture having push buttons with UP and DOWN legends at intermediate landings shall be provided. Button identification as specified for Person with disabilities per latest ADA regulation (ADA rule 4.10.3) shall be provided.
4. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered shall be provided. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing. The Push Buttons shall be round having a Metalized Halo and center jewel. The metalized halo shall be from differrent color and approved by ELES Engineer.
5. Stops, registered by momentary actuation of landing buttons. All stops subject to respective car or landing button being actuated sufficiently in advance of arrival of car at that landing to enable stop to be made. Direction of travel for idle car established by first car or landing button actuated.
6. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
7. Elevators to park at the secure landing level selected by the Engineer shall be provided.
8. Push-button units to be PB-46 NEMA-4 Series or approved equal with button identification as specified by latest ADA regulation shall be provided.
9. Emergency stop shall be key-operated rather than a push-pull arrangement with key removal only in off position.
10. All elevator car control panel operating devices shall be designated by Braille and by raised standard alphabet characters for letters, Arabic characters for numerals, and standard symbols as required by the Code and ADAAG.
11. Lettering shall have a highly visible coloring, such as white, that is permanently affixed.
12. Independent Service: Provide a key switch in the car operating panel which, when actuated, shall cancel previously registered car calls, disconnect the elevator from the hall buttons, and allow

operation from the car buttons only. The car door shall remain open unless closed fully by the door close button.

13. Two-Stop Collective Simplex Automatic Operation: The two-stop collective simplex automatic operation shall be used and checked for the following:

    a. The System shall be designed so that when the car is standing at either terminal landing, pressure on car button for the other terminal shall automatically dispatch car to that landing. The pressure of landing button at either terminal landing shall call the car automatically to that landing. If a landing call is registered while the car is making its trip that call shall remain registered until the car responds to that call. If no car calls are registered, the car shall start automatically and respond to hall calls. Provide a time-limit relay arranged to hold the car at landing at which it has stopped for predetermined time after car stops. After all car landing calls have been answered, the car shall remain parked at landing where last used with car and hoistway doors closed until another call is registered. Pressing the landing button at floor at which car is parked shall automatically open car and hoistway doors. In all normal operations, the starting of the car shall be contingent upon establishment of hoistway door interlock and car door circuits.

    b. Automatic dispatching operation: All two-stop elevators shall include “Step-in-and-Go” feature. Calls for the opposite landing will be automatically set when the elevator opens its doors for a hall call. This feature shall be provided for all elevators that have public access for two stops (i.e., any elevators with key operated service landings will be included).

14. Position Indicators

    a. Car indicator: Car indicators shall be in accordance with ADA requirements. Car indicators shall be mounted in vertical row in car-operating panel to show the position of the car in hoistway by illumination of indicators corresponding to landing at which the car is stopped or passing. The finish for exposed-to-view metal components shall be Stainless Steel.

    b. Landing indicator: In accordance with ADA requirements a two-element direction-of-travel landing indicator shall be mounted above the call station or hoistway entrance as shown. The landing indicator shall include one red and one white indicator. The direction of car's operation shown by illumination of a red indicator for DOWN and a white indicator for UP.

    c. In-car signals: An audible signal indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.

    d. Landing signals: An audible signal at each hoistway entrance indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction shall be provided.

15. Lighting

    a. Machine Room Emergency Lighting: Emergency lighting shall be provided in each elevator machine room.

    b. There shall be a minimum of light lighting fixture.

    c. Car interior: A LED fixture, 120-volt operation, with clear prismatic glass diffuser, flush mounted in ceiling, cool white bulbs shall be provided. The illumination level shall be 15-foot candles minimum at car operating panel.

    d. Car top and underside of car floor: A medium-based porcelain lamp receptacles, with wire lamp guards shall be provided.

    e. Car Emergency Lighting:

        1) Fixture: Recess mounted, with stainless steel frame, location as shown.

        2) Diffuser: Prismatic poiycarbonate plastic.

        3) Lamps: Two, size 16-51.

16. Remote power supply:

a. Power pack: Sealed gel cell battery with integral regulating charger and an alarm bell.

b. The remote power supply shall be capable of operating bell for one (1) hour minimum and light at car-operating panel at 0.2 low candles minimum for four (4) hours minimum.

c. Location: The remote power supply shall be located in the top of the car or COP with easy access provided.

17. Inspection Operation: The key switch in car shall nullify car and the landing buttons permitting operation of elevator from top of car for inspection purposes:

a. Top of Car Inspection Station: The Inspection Station contains continuous pressure UP and DOWN buttons, emergency stop button and toggle switch to activate inspection devices. The device shall also have an 110v ac outlet for extension cord and provided with a light and guard.

18. Leveling: Automatic leveling device to stop car within 1/8 inch of landing level regardless of load or direction of travel. Landing level maintained within leveling zone irrespective of hoistway doors being open or closed.

C. Emergency Service

1. Controls to return elevator to designated floor shall be provided by means of key-operated switch outside street or ground floor hoistway entrance in compliance with ANSI/ASME A17.1.

2. In-car control during emergency operation shall be provided by means of key switch in compliance with ANSI/ASME A17.1.

3. Terminals on elevators controllers for connection of circuit from heat and smoke sensing devices shall be provided with wiring from sensing devices to elevator controller.

D. Telephone Facilities

1. Provide all audio/visual communication, signaling, and monitoring in accordance with ADA and ANSI. “Hands-free” phone integral with a control panel, mounted in accordance with ADA requirements; having inscription EMERGENCY TELEPHONE as specified for a Person with disabilities. Finish exposed-to-view components to match the stainless steel control panel. The color of the letters shall contrast with the panel.

a. Provide emergency communicators in accordance with ADA requirements to include an auxiliary push button to summon help and visual feedback indicating that the call has been responded to.

2. Provide wiring and jacks for a portable self-contained battery-powered maintenance telephone system. The jacks shall be located on car top, inside car, and in machine room. Furnish three (3) telephone instruments for the use of maintenance personnel.

E. Electrical Equipment

1. Electric equipment for elevator shall be designed, selected, and fabricated in accordance with NEC, NEMA, IEEE, ANSI Standards, applicable jurisdictional codes, and additional specified requirements. All equipment including motors, controllers, service cabinets, circuit breakers, switches, panelboards, indicators, lighting, wiring, conduit, boxes, and other appurtenances for proper installation and operation of the elevator shall be furnished and installed by the Contractor.

2. Cable and wire for external circuits between the various items of elevator equipment, exclusive of the traveling cable, shall comply with the requirements specified below. The talk pair of the voice communications intercom system shall be shielded with 0.008-inch, minimum, copper shield.

a. General Requirements for Single-Conductor and Multiple-Conductor Cable:

1) Type and size: As shown or as required by code.

2) Rated voltage: 600 volts.

3) Conductors:

a) ASTM B3 or ASTM B8 annealed copper

b) Size 10 AWG and smaller: Solid or Class B or Class C stranded.

c) Size 8 AWG and larger: Class B stranded.

d) Other constructions as specified.

4) Standards: Except as modified, wires and cable complying with the following:

a) Cross-linked polyethylene (XLPE) insulated cable: NEMA WC 70.

b) Other cable: NEMA WC 70.

5) Non-metallic jacket for single-conductor cable and individual conductors of multiple-conductor cable and as overall covering on multiple-conductor cable:

a) Chloro-sulfanated polyethylene or cross-linked polyolefin.

b) Cross-linked polyolefin complying with the following physical requirements:

b. Properties tested in accordance with NEMA WC 70 if ethylene-propylene-rubber (EPR) insulation is used or with NEMA WC 70 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.

1) Tensile strength, minimum pounds per square inch: 1,800.

a) Elongation at rupture, minimum percent: 150.

2) Aging requirement: After 168 hours in air oven test at 100EC, plus or minus one degree C:

a) Tensile strength, minimum percentage of unaged value: 100.

3) Elongation at rupture, minimum percentage of unaged value: 80.

4) Oil immersion: 18 hours at 121EC, plus or minus one degree C, ASTM D471, Table 1, No. 2 oil:

a) Tensile strength, minimum percentage of unaged value: 80.

b) Elongation at rupture, minimum percentage of unaged value: 80.

c) Jacket materials other than cross-linked polyolefin complying with NEMA WC 70. Jacket material free of PVC and PVC-based compounds.

5) Flame retardancy: Single-conductor and multiple-conductor cable demonstrating flame retardancy in accordance with the following:

a) Single-conductor cable and individual conductors of multiple-conductor cable passing vertical flame test in accordance with UL 1591 or NEMA WC 70. Cable size for testing: 14 AWG.

b) Single-conductor and individual conductors of multiple-conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 1202.

c) Multiple-conductor cable passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202.

c. Applied voltage testing:

1) Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric strength test, i.e., six-hour water-immersion test.

2) For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.

d. Test Procedures:

1) Polyethylene insulated conductors: In accordance with NEMA WC 70

2) Other conductors: In accordance with NEMA WC 70.

e. Single-Conductor Cable:

1) Insulated with ethylene-propylene-rubber with non-metallic jacket or unjacketed filled cross-linked polyethylene. UL-labeled Type RHW or XHHW.

2) Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

f. Multiple-Conductor Cable

g. Individual conductors:

1) Number of conductors: As shown or as required by code.

2) Construction: Complying with one of the following:

a) Insulated with ethylene-propylene-rubber, with or without nonmetallic jacket as specified.

b) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV, without outer jacket.

c) Insulated with filled cross-linked polyethylene without jacket.

h. Phase and neutral conductors: Individually insulated.

i. Neutral conductors: Same size as phase conductors.

j. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.

k. UL-listed as Type RHW or XHHW.

3. Conductors assembled with non-wicking, flame-retardant filler to form cable of circular cross section.

4. Metallic-Sheath: Provide one of the following:

a. Continuous smooth aluminum sheath in accordance with NEMA WC 70.

b. Continuous corrugated aluminum sheath in accordance with NEMA WC 70.

c. Interlocked aluminum tape armor.

d. Multiple-conductor cable provided with overall nonmetallic jacket as specified.

e. Cable UL-listed as follows: Metallic-sheathed cable: Type MC, suitable for wet and dry locations.

5. Color coding:

a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

b. Control cables: In accordance with NEMA WC 70

6. Fixture Wire: UL 62, with the following additional requirements:

a. Type: Suit temperature rating of lighting fixture, minimum 194EF.

b. Conductor: Stranded copper conductor 16 AWG or larger as shown.

c. Bare Conductor: ASTM B3 or B8, annealed copper conductor; 8 AWG and larger, class B stranded.

7. Traveling Cable

a. The elevator car traveling cable shall be type ETT conforming to the requirements of the NEC with minimum conductor sizes as specified in the NEC. Individual conductors in the cable shall have a distinctive color code for identification. Each traveling cable shall have one two-conductor stranded 18 AWG, twisted shielded pair for elevator intercom and a minimum of ten spare conductors. Traveling cable exceeding 100 feet in length shall have steel supporting fillers. Traveling cable 100 feet or less in length shall have steel or non-metallic fillers.

b. For surface elevators only, the traveling cable shall be provided in addition to the above requirements, with one RG-6u coaxial cable, and one two-conductor, twisted shielded pair, stranded 18 AWG power cable for CCTV camera.

8. Connector, Terminal Lugs and Fittings

   a. In accordance with UL 486.

   b. For 10 AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.

   c. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with insulating sleeve or heat shrinkable insulator for insulation grip.

   d. For multiple-conductor cable: Watertight aluminum fittings with stainless steel pressure ring and set screws or compression cone for grounding of aluminum sheath of Type MC Cable.

   e. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.

   f. All wires shall run inside conduits. Wires and cables shall not be spliced inside or outside of conduit. Wire and cable shall only be connected at terminal strips or devices inside boxes, controller or approved enclosures.

   g. Self-extinguishing nylon bundling straps having a temperature range of minus 65EF to plus 250EF shall be used for bundling or cabling of conductors where required. Strap shall have a hub complete with stainless steel locking barb on one end and a taper on the other.

9. Conduits and Fittings

   a. Rigid conduit and fittings shall be UL-Listed rigid galvanized steel conforming to the requirements of UL 6 and ANSI C80.1. The minimum diameter shall be 3/4 inch for power circuits, one inch for fire and intrusion circuits, and two inches for audio and control circuits.

   b. Liquid-tight flexible conduit shall conform to the requirements of UL 360 and consist of a flexible galvanized steel core containing a copper bonding conductor spiral-wound between convolutions and a neoprene or PVC jacket overall. Fittings for liquid-tight flexible conduit shall be watertight and shall conform to the requirements of UL 514.

   c. All conduits (rigid steel and liquid tight flexible) should be permanently secured with metallic clamps. Zip ties are not acceptable to use as permanent use.

10. Auxiliary gutters, wireways, and raceways shall be constructed of galvanized sheet steel conforming to the requirements of the NEC and shall be UL-listed. Raceway, conduit and wireways within the hoistway exposed to public view shall be concealed within steel cladding.

11. Electrical Boxes

    a. Outlets, junction and pull boxes shall be galvanized sheet steel or galvanized malleable iron, cast iron or ductile iron conforming to the requirements of UL 50, UL 514 and NEC paragraph 370-C. Pull boxes shall have a screw cover with a liquid-tight gasket.

    b. Junction boxes on car bottom and hoistway connecting the traveling cable shall contain approved terminal blocks for connection of traveling cable conductors. Terminal blocks shall have indelible identification numbers for each terminal connection.

    c. All wire connection terminal blocks shall have the same identification number as labeled on the associated electrical wiring. All electrical wires shall use a labeling tube and heat shrink and match the terminal numbers.

    d. During field installation of junction boxes or control boxes, the Contractor/Sub-Contractor shall not drill or cut into the top sides of the box for wiring.

    e. All boxes shall be accessible without removal of other components.

    f. All boxes in the machine room or pit shall be mounted on strut channels in order to prevent future corrosion and water damage. The strut channels shall be mounted on the wall and has a minimum of one and one-half (1 ½") inches thickness and eighteen (18") inches above the floor.

    g. All boxes (junction, pull-through etc.), conduits and any electrical devices shall be installed in height of twelve (12") inches minimum from the elevator pit floor. There shall be no electrical conduits installed on the elevator pit floor.

    h. All solid state and electrical components located on top of the car enclosure or in the hoistway shall be installed within NEMA 4X enclosures.

12. Disconnect Switches for Car Lights and Mainline Power

    a. Disconnect switches shall be the following: UL 98, NEMA KS 1, heavy-duty, quick-make/quick-break switching mechanism with operating handle external to enclosure, with positions labeled ON and OFF, non-defeatable interlock to prevent opening of enclosure door when switch is ON. Enclosures shall be NEMA 250 Type 4X. Label disconnects switches shall be in accordance with the NEC.

    b. The mainline power disconnect switch shall be located in close approximation to the machine room entrance and shall be easily identifiable from other disconnects.

13. Circuit Breakers and Panelboards

    a. Circuit breakers shall be the following: NEMA AB 1, UL 489, molded-case, bolt-on quick-make/quick-break, mechanically trip-free switching mechanism, with a thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Circuit breakers shall be designed to carry continuous rating in ambient temperature of 40ºC.

    b. Panelboards shall be the following: UL 50, NEMA PB 1, latch and handle in accordance with UL 50, minimum side gutter size of four inches, bus bar of 98-percent-conductivity copper with contact surfaces silver-plated or tin-plated, rating of neutral, and ground buses equal to phase bus rating, neutral bus mounted on insulated block, neutral and ground buses equipped with integral mechanical connectors, one (1") inches high engraved plastic nameplate with two (2) inch high letters on black and attached with stainless steel fasteners. Enclosures shall be NEMA 4.

14. Pit Receptacles and Lights

    a. Electrical power receptacles shall be furnished and installed in the elevator hoistway, pit, and top of car as shown or required by code. Each receptacle shall be duplex, ground fault interrupter type, resettable at the receptacle; waterproof; grounded; rated for 120 volts at 20 amperes.

    b. Maintenance lighting shall be furnished and installed in the elevator hoistway as shown or required by code. Lighting shall be vapor-tight service lights with quick start type PL compact

fluorescent lamp. Furnish and install light switches; waterproof; grounded. The light switches shall be so located as to be accessible from the pit access door.

15. Drive Unit Motor

    a. Motor shall be designed specifically for elevator service. The drive motor shall be of the alternating current, intermittent duty, 120 starts per hour, 1.15 service factors, squirrel cage induction type design adapted to the severe requirements of elevator service. The elevator drive motor shall be single-speed. The motor shall be suitable for operation on a 480-volt, three-phase, and 60-Hertz supply and capable of developing the required starting torque.

    b. The motor shall be rated in accordance with NEMA Standard MG 1 for 60-minute rating motors and shall have sufficient capacity to operate the elevator with specified rated load at specified rated speed without overheating. The insulation and the starting and running torque of the motor shall be capable of permitting operation in accordance with NEMA MG 1. Standard factory motor test data and motor dimensions shall be submitted to the Contractor for approval. Each motor nameplate shall include the motor horsepower (HP) rating, voltage, full-load amperes, locked rotor amperes, full-load speed, design temperature rise, and NEMA design rating of the motor. Each motor shall be provided with a ring or other suitable lifting means. The motor frame shall be tapped and drilled for a copper cable grounding connection.

    c. Insulation of windings shall be NEMA Class B, fully impregnated and baked to prevent the absorption of moisture and oil. The insulation resistance between motor frame and windings shall be greater than one megohm.

    d. Motor bearings shall be of the ball or roller type arranged for grease lubrication and fitted with grease gun connections and drains plugs or fitted with sealed-for-life bearings. The bearings shall incorporate dust-tight lubricant seals.

    e. Motor shall be provided with an electronic soft start feature and thermal overload protection for each phase.

    f. Connect motor and pump with multiple V-belt.

        1) Belts and sheaves shall be sized for duty involved and designed to prevent any metallic contact between motor and pump shaft.

        2) Furnish and install isolation units of rubber in shear to prevent transmission of pump and motor vibration to building.

        3) Furnish and install expanded metal sheave guard that can be easily removed for servicing and inspection.

16. Elevator Controller

    a. An Allen Bradley (or ELES Engineering approved equal) PLC-based: The elevator controller shall be provided, governing starting and stopping as well as preventing damage to the motor from overload or excessive current. It shall automatically cut off the motor current and bring the car to rest in the event any of the safety devices are activated.

        1) The system shall coordinate the functioning of elevator drive unit relative to actual location and status of elevator. It shall interface with door control and all required safety circuits, switches and devices. The controller shall be mounted in a NEMA 4X stainless steel air-conditioned cabinet within the machine room.

        2) The diagnostic system shall be an integral part of the controller and provide user-friendly interaction between the service person and the controller system.

        3) The supervisory logic shall be performed by a main controller or coordinated between the elevator controllers which will interface directly into the Allen Bradley DH485 (or ELES Engineering approved equal) protocol Remote Monitoring network, transmitting data from the elevator controller through a data concentrator to the Authority's AEMS RTU computer control and data system. The supervisory logic will coordinate dispatching assignments,

interfacing operational demand data accumulated from car and corridor operating fixtures, selector, and door control functions.

4) The controller shall be capable of operating within an operating temperature range of 32^0F to 140^0F with non-drip environment and no more than 90 percent relative humidity. However the air conditioner on controller cabinet shall maintain the operating temperature in range of 50^0F to 80^0F.

b. An Allen Bradley CompactLogix 1769-L32E (or ELES Engineering approved equal) based PLC control system shall be provided. (Take to #1)

1) The exclusive Allen Bradley DH485 protocol data port will transmit data from the elevator controller to the station or facility data concentrator. The Contractor shall provide a controller data interface to a DH 485 network. Contractor shall provide Data cables to connect from the PLC controller to data concentrator in the station and available for connection to the controller DH485 interface. The Contractor shall pull Belden 9842, or ELES Engineering approved equal, cables to connect the controller into the monitoring DH485 network. The DH485 controller interface shall be programmable for date rates up to 115 Kbps. The interface shall allow other nodes such as other elevators and escalators to be readily incorporated into the DH485 network.

2) A data concentrator PLC shall be installed using an Allen Bradley CompactLogix 1769 L32E or SLC5/05 PLC per station to function as data concentrated or to consolidate data from all controllers in the station. The software for the data concentrator shall receive controller data over the local monitoring DH485 network and provide formatted data to the AEMS RTU through an RS232 link. The data concentrator shall provide an Ethernet port for interfacing with the WMATA wide area network. A data concentrator connection to the WMATA wide area network shall be provided.

3) The PLC shall accommodate the following Signal List, as applicable, and provide data to the data concentrator as specified in specification.

4) The PLC CPU module shall store the last 99 faults, accessible via laptop connection, controller fault/status display and remote communications. The Contractor shall provide WMATA with a programming and monitoring unit, such as a laptop computer with the newest version of Allen Bradley RS-Logix and any other software required to setup and program all electronic items in the control system, for each elevator, for the purpose of troubleshooting and remote monitoring modifications. The laptop should allow uploading, editing, and downloading any software that is being used on this elevator for any operation.

5) An Allen Bradley PanelView Plus 6, Automation or ELES Engineering Approved Equal, fault/status display/interface shall be provided in Controller cabinet. Control system timers and other setup criteria shall be programmable through this unit. All fault, status, and setup data shall be stored in the controller CPU module.

6) In cases where the programming is done by the supplier, the supplier shall provide a copy of all working programs, including labels for all inputs and outputs, data tables and internal logic points, on Flash Drives as well as a printed program listing. The programs and setup data shall require a password for access and modification. The password shall be provided to ELES Engineering as part of the Submittal.

7) The main control of an elevator shall contain at least the following devices or electronic sensing: Phase failure line voltage monitor, motor current, and ground fault monitor.

8) The controller cabinet shall contain a permanently mounted fault indicator panel with LED indicator lights. Tripped safety devices, door position, door reversal, car running status, and control system status shall be indicated.

9) All terminals shall have identification markings and all wires, including field wires, shall be provided with permanent heat shrink sleeve cable markers. These wiring identifications shall be provided in the wiring diagram at each end of the circuit connections.

10) The controller shall be equipped with the AC vector drive installed in-line before the motor contactor and the motor.

11) The AC vector drive shall be capable of accelerating and decelerating the motor smoothly and gradually.

12) Adjustable settings for acceleration and deceleration ramps shall be provided.

13) The controller shall have, at least, one dedicated serial port for interface to the DH485 monitoring network and programming access without disconnecting any other port.

14) The Programmable Controller shall have, at least, one dedicated port to support the controller fault/status display.

15) The controller PLC shall provide the following Remote Monitoring and diagnostic network support:

    a) All applicable faults, statuses, and data listed in Table 3 shall be provided.

    b) Fault indications shall remain until reset in the controller.

    c) Status and analog data shall be provided for the duration of the condition.

    d) Software in the controller PLC shall format monitoring data responses to data concentrator polling as specified in the specification.

    e) The monitoring data port in the controller shall be setup for DH485 protocol with the port network identification number programmed for the particular elevator identification. For instance, identification number 11 applies to elevator 1, 12 to elevator 2, etc.

    f) All faults, statuses and data shall be held by the controller CPU and sent from the CPU when polled by the data concentrator.

16) Provide sufficient non-volatile CPU memory, for non-volatile retention of program memory, system status and operating parameters.

17) Diagnostics

    a) The processor shall have built-in diagnostics and self-test, such that each time power is cycled, the processor does a complete CPU and RAM memory test. Additionally the power-up test will momentarily light up all diagnostic LEDs to be sure they are working. A power up test will not be performed if the internal flag (bit) for Fireman's Service Phase I is latched. The processor shall be capable of reporting major and minor fault codes and processor status information back to the data concentrator, provided the fault is not a catastrophic hardware failure where the processor is unable to power up.

    b) The processor shall have a built-in watchdog timer to ensure that all processor program scans occur within the time limit set by the watchdog timer.

    c) The processor shall have individual LED indicators that are clearly visible and labeled for easy identification. At a minimum the following indicators must be provided:

    d) (1) CPU is in RUN mode

    e) (2) CPU is FAULTED

    f) (3) CPU battery is LOW

    g) (4) I/O points are FORCED and are not under program control

    h) (5) COMMUNICATION channels are active.

17. Input/Output Modules

    a. The Input/Output modules shall be compatible with the PLC processor I/O structure. Each module shall be provided with a detachable terminal strip to connect wiring to the module. Each wire on the terminals shall be identified by the module terminal.

b. Discrete Input Modules: Suitable for the input voltage and compatible with the Allen Bradley system

c. Discrete Output Modules: Suitable for the voltage and load and compatible with the Allen Bradley system.

d. Analog Input Modules: Converts analog signals to proportional twelve-bit binary values. The module shall accept 4 to 20 mA signals. Provide modules compatible with the Allen Bradley system.

18. I/O Chassis and Power Supply

a. The controller chassis shall have an additional three spare modules.

b. Power supplies shall provide power to the PLC processors, I/O and other function modules. The power supply shall be suitable for operation of 120 VAC, single phase power. Power supply capacity shall be a minimum of 150% of the connected load.

19. Air Conditioning

a. Provide an independent air conditioning unit with drip-free active condensate evaporation system for each controller to maintain manufacturers recommended operating temperatures. The air conditioner shall be equipped with fully-programmable digital controller with temperature and pressure monitors for smarter air conditioner. The air conditioner shall have NEMA 4X enclosures and use 120 VAC or 24 VDC power source for calculated BTU/hour.

20. Selective Collective Operating: As defined by ASME A17.1 and shall be the pressure upon one or more car buttons to correspond to landings in the order in which the landings are reached by the car, irrespective of the sequence in which the buttons are pressed, provided the hoistway door interlock and car door switch circuits are completed. During this operation, the car shall also answer calls from the landings, which are in the prevailing direction of travel. Each landing call shall be canceled when answered.

a. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing.

b. Operation shall be automatic by means of the car and landing buttons. Stops registered by the momentary actuation of the car or landing buttons shall be made in the order in which the landings are reached in each direction of travel after the buttons have been actuated.

c. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.

d. Should both an up and a down call be registered at an intermediate landing, only the call responding to the direction in which the car is traveling shall be canceled upon the stopping of the car at the landing.

21. Supervisory Control: A processor-based system to coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures and other special feature commands issuing from computer processing, selector and door control functions. Incorporate in the system specific operational features as herein described.

a. Allocate service to demand, make decisions to prevent crowding, save energy, and provide efficient coverage throughout the building. Respond in real time to prevailing traffic conditions as well at historical traffic patterns.

b. Constantly compare passenger demand, car load, anticipated demand, car motion status, machine status and other prevailing conditions and evaluate this information in the context of the following dispatching approaches:

1) Give priority to contiguous calls, assigning calls on adjacent floor to the same car if other criteria is satisfied.

2) Give priority to coincident calls, having the same car let a riding passenger off and a waiting passenger on at the same floor.

3) Anticipate demand-based on hall calls and car calls already registered and floors with a high possibility of demand.

4) Evaluate relative system response time for each car in the group, weighing all of the above factors.

5) Allocate calls and position cars to minimize waiting time, response time and travel time. The other elevator shall respond for hall calls without any delay after the first elevator leaved the door zone.

6) When there is a hall call registered and an elevator left the landing, the other elevator shall run toward opposite landing.

c. Provide the capability to make both car to call or call to car assignments.

d. During light traffic conditions, assign cars without demand to specific parking areas until requested for a hall call. Continuously evaluate dispatching assignment and immediately release a car from its assigned area to meet heavy demand elsewhere in the building.

e. In determining relative system response time for a car to answer a hall call, factor in round-trip calculations for each car as well as other system parameters before deciding which car shall respond to a hall call.

22. Other Features:

a. Independent Operation: Provide a two-position keyed switch (ChicagoLock 7500) marked Independent Service, OFF and ON in the lower portion of the car operating panel of all cars. The switch shall be spring-loaded type. When placed in the ON position, the car will be removed from the automatic operating system and will not respond to demands registered at the hall push buttons. It will respond only to floor with doors open until another demand is registered in the car. Demands registered at the landing will remain registered until answered by another elevator. The car only responds to car calls and that the doors remain open after a stop until closed by continuous pressure on the door close button.

b. The controller shall be designed to operate automatically on standby power.

c. Hoistway Access Switches (ChicagoLock 7500) shall be provided at all landings. The hoistaway access switch shall be located on the centerline of the right door jamb at the height 60” minimum and 72” maximum from the finished floor.

23. Machine Room Two Way Communication Device: Provide within each elevator machine room a two way communication device that will interface with any type of ADA compliant telephone. The device shall be mounted directly on or within hands distance proximity to the elevator controller.

24. Any junction boxes installed in the machine room or hoistway shall be accessible for Maintenance.

a. Drilling or opening the top end of the enclosure is not acceptable

b. Wire nuts or splicing without terminal strips is prohibited.

c. All openings shall be properly sized for the conduits.

F. Emergency Lowering

1. Provide a separate battery powered unit that senses loss of power and which shall operate as follows:

a. Elevator automatically descends to bottom landing.

b. Doors open automatically when car arrives at bottom landing and then close as required by Code.

c. Elevator shall remain inoperative until normal power is restored.

2. The system shall differentiate between actual power failure and manual operation of disconnect switch.

3. Failure protection (operational/power) battery shall be a 12 volt minimum, sealed, lead-acid, or approved alternative. The separate box shall be used for battery and not stored within the main controller.

   a. The Unit shall be connected to a power source

   b. The Unit shall automatically maintain the battery at its proper charge.

4. Provide a manual lowering valve to allow the car to return to the lowest landing. The manual lowering valve shall be easily accessible and reachable.

5. Provide all wiring, sensors, and associated connections to the main line power and disconnect.

G. Elevator Hoistway Entrances and Doors

1. Doors of elevators shall be of the horizontal sliding type, single-speed, center-opening. All elevator door openings shall be a minimum of 42-inches wide per the Americans with Disabilities Act.

2. Entrance frames shall be of welded or bolted construction for complete one-piece unit assembly. All frames shall be securely fastened to fixing angles mounted in the hoistway and shall be type 316 stainless steel. Provide an additional type 316 stainless steel sill angle support. The landing sills shall be extruded stainless steel with a mill finish.

3. All materials and finished surfaces exposed to public view shall be stainless steel with embossed finish and/or glass panels as indicated on the Contract drawings or below ground station(s) with bronze (or anodized aluminum). Glass panels (if provided) to be completely flush with door assembly. In a glass hoistway, the struts or any brackets should not be visible to the public.

4. Fascia and Dust Cover in the hoistway shall be galvanized or type 316 stainless steel and extend at least the full width of door opening on each side. A toe guard shall be fastened to the sill at the lowest landing.

5. Hoistway doors are to be stainless steel or below ground stations with bronze (or anodized aluminum) and provided with keyways as required for operating mechanisms and door hangers. Provide glass panels that are completely flush with door, as indicated in A17.1. Each door panel shall have stainless steel bottom guides that run in landing sill slots. Guides shall be replaceable without removing door panels. All doors shall have fixed fire Gibs.

6. Interlocks and Contacts

   a. The doors at each hoistway entrance shall be equipped with approved hoistway door interlocks of the hoistway unit system type tested as required by the Code. Interlocks shall prevent operation of the car away from a landing until doors are locked in the closed position. Interlocks shall prevent doors from opening at any landing from the corridor side unless car is at rest at that landing, or is in the leveling zone and stopping at that landing.

   b. Provide key-operated hoistway door unlocking devices. A device shall conform to the requirements of the Code and shall permit authorized persons to open the hoistway doors from the landing when car is away from landing. The key for emergency use shall be mounted in a Knox-Box as required by NFPA 72 Code.

7. Provide raised floor/level designations in characters and Braille on each jamb at 60 inches from floor to centerline. Characters shall be two inches high and in accordance with ADA requirements.

8. Sills shall be stainless steel and shall be supported on and attached to galvanized steel anchors securely fastened to the sill plate support. The sill and its assembly shall be capable of supporting 1260-pound service load for the transfer cart used by WMATA. Grooves for the door guides shall be

machined with minimum clearance for the guides. The Contractor shall provide sill plates. Sill plates and all other sill support structure including shims and jack bolts shall be hot-dipped galvanized.

9. Struts and closer angles shall be hot-dipped galvanized structural steel angles of sufficient size to accommodate and support the hoistway door header plate. Angles shall be continuous and securely bolted to the sills and building beams or structure above.
10. Hanger supports shall be 1/8-inch minimum thickness formed sections securely bolted to the strut angles.
11. Fascia Plates: Galvanized Steel cladding reinforced to ensure a flat, even surface throughout, and shall be securely fastened to hanger supports and sills above.
12. Dust Covers: Galvanized or Stainless Steel cladding which shall extend over the hanger support the width of the jamb opening plus the jamb flanges, at the top landing for which fascia plates are not supplied.
13. Hanger cover plate sections above the door openings shall be arranged for opening or removal from within the car.
14. Sill guards: Sill guards (galvanized steel cladding) shall be supplied for the lowest landing. On glass hoistway, they shall extend the full width of the hoistway and to bottom of pit.
15. Door hangers and tracks shall be provided for each hoistway, sliding door sheave type, two-point suspension hangers and tracks, complete. Sheaves shall not be less than 2-1/4 inch diameter with ball bearings properly sealed to retain grease lubrication and shall be mounted on stands arranged for attaching to the doors by two cap screws. Hangers shall be equipped with adjustable ball bearing rollers to take the up-thrust of the doors.
16. The tracks shall be high-carbon steel or formed steel with nylon inserts, shaped to permit free movement of the sheaves.
17. All inside surfaces of doors shall have baked-enamel finish as shown on the finish schedule.

H. Elevator Components

1. The elevator car and car components shall conform to the requirements of the Code, and shall operate without squeaks or metallic sounds. The entire car assembly, including car frame and platform, shall be free from warps, buckles, and squeaks and rattles. Joints shall be light-proof.
2. Frame and Platform
    a. The car frame shall be constructed of structural steel members. The platform shall consist of a steel frame with necessary steel stringers all welded together. The frame and platform shall be braced and reinforced to prevent the transmission of strain to the elevator car. Steel framing shall conform to the requirements of ASTM A500, Grade B, modified to minimum yield strength if required. The variation in straightness of individual members and the frame as a whole shall not exceed 1/8 inch. Secondary straightening may be performed if necessary. The car enclosure shall be securely fastened to the car platform and so supported that it cannot loosen or become displaced during ordinary service, on the application of the car safety or on buffer engagement.
    b. A platform shall be provided with a steel floor designed for specified loading and sealed watertight. The platform shall be isolated from the cylinder by suitable rubber pads or other equally effective platen isolation.
    c. All structural steel in the frame and platform shall be hot-dipped galvanized.
3. Car enclosure walls shall be structural steel tubing with stainless steel cladding, in-filled with aluminum framed laminated fully tempered safety glass. Stainless steel cladding shall be #4 satin finishes.
4. Railings and Handrails: Car handrails shall be 1/2 inch by 6 inch stainless steel #4 satin finished tubes suitably mounted.

5. Car thresholds shall be stainless steel with a non-slip surface.
6. Toe Guard Aprons
    a. The toe guard apron (cladding) at entrance side of elevator cab shall be not less than 16 U.S. Standard Gauge (USSG) galvanized steel or stainless steel, and shall extend at least three (3") inches beyond entrance jambs at each side. The toe guard shall have a straight vertical face, extending below the level of finished car floor, of not less than the depth of leveling zone plus three inches. The bottom of the guard shall extend three (3") inches below vertical face and be beveled at a 15-degree angle from the vertical. The toe guard shall be secured to car platform construction and be reinforced and braced to withstand a constant force of 150 pounds on its face without permanent deformation or deflection exceeding 1/4 inch.
    b. On glass elevators, the toe guard shall extend full width of cab.
7. Suspended Ceiling
    a. The suspended ceiling shall be faced and edged with solid stainless steel panels, 0.075-inch thick with a fully adhered three quarters (¾") inches thick core of noncombustible, sound-absorbent material and backed with galvanized sheet steel. ASTM A653M, G90 coating or better.
    b. Mounting brackets and any necessary holes for the CCTV camera shall be provided on the top of the ceiling, as further specified in Section A. Coordinate bracket configuration and location with the CCTV Sub-Contractor.
    c. Mounting brackets and any necessary holes for the smoke and fire detection sensors shall be provided on the top of the ceiling, as further specified. Coordinate bracket configuration and location with the fire and intrusion system Sub-Contractor.
8. Laminated Tempered Safety Glass
    a. Glass shall be laminated fully tempered safety glass conforming to ANSI Z97.1 and the requirements of Specification Section 08_81_00.
    b. Glass shall be laminated. Heat-strengthened, safety glass shall conform to requirements of ASTM C 1048 and ANSI Standard Z97.1 and shall consist of two pieces of one quarter (¼") inch thick glass and a 0.060 inch thick polyvinyl butyryl interlayer, laminated together.
    c. Color: Tint by Globe-Amerada Co., used as a standard of quality, or comparable and approved equal.
    d. Weatherproof tape for field installation of final edge seating shall be compatible with the interlayer.
9. Dry Pressure Glazing Materials
    a. The setting blocks, edge blocks, and face gaskets shall be ozone-resistant, virgin neoprene.
    b. Setting blocks for installation at each quarter point of the sill shall be 90 Durometer, shore hardness, approximately full channel width, four inches long, and high enough to afford correct cover and 3/8-inch edge clearance for the glass.
    c. Edge blocks, for vertical installation at the bottom of each joint channel, shall be 50 durometer, shore hardness approximately full channel width, three inches long, and provide 3/8-inch edge clearance for the glass.
    d. Face gaskets shall be continuous, 50 durometer hardness, and provide 3/16-inch face clearance both inside and outside.
10. Sub floor material to be nominal one quarter (¼") inches stainless steel to prevent water infiltration between finished floor, cab and platform base.

    Floor covering: Elevator car flooring shall be "Grano nTx" Nora Design "5303 Frankincense" color. (The bonding agents shall be Planiprep Skim-coating, and Mapei Primer T. or approved equal).

11. Emergency exit: Car shall have a top emergency exit conforming to the requirement of the ASME Code, and the applicable jurisdictional requirements. The door shall open toward the top of elevator and shall have a latching mechanism to keep it in place.
12. Ventilation: A 350-cfm two-speed exhaust fan for continuous car ventilation shall be provided and located above the car ceiling or outside the enclosure.
    a. Ventilating fans shall be securely mounted in place.
    b. Ventilation openings shall comply with the ASME and local codes, and shall be suitably sized and distributed to provide uniform airflow within the car.
    c. Connect continuous ventilation fan to emergency power system. Provide battery backup for fan operation of at least 1 hour in the event of power loss.
    d. The exhaust fan shall be controlled from the car operating panel with EPCO-1 (similar to existing WMATA Elevators keys).
13. Cab air conditioning (if applicable), in addition to the exhaust fan, shall be installed as specified in the contract and shall be a self-contained, packaged design for easy mounting, maintenance, and replacement.
    a. Packaged air conditioners shall be installed on the top of the elevator car.
    b. If not installed in original scope, space provisions shall be made for future installation of packaged air conditioning units.
    c. Installation area shall be coordinated with electrical, structural, and other trades to ensure no interferences with current or future installation.
    d. Electrical power of the proper voltage and capacity shall be available for the air conditioning unit installation current or future.
14. Lighting Fixtures and Plug Receptacles
    a. Car lighting shall provide a minimum of 15-foot candles measured at any point on the cab floor and shall of the LED type. Car lighting shall be provided with emergency battery backup upon failure or interruption of normal car lighting. Emergency lighting unit shall provide required lighting for a minimum of four (4) hours. Battery charger shall be capable of restoring battery to full charge within sixteen (16) hours after resumption of normal power.
    b. Exterior car lighting shall be as specified. On glass-enclosed elevators, they shall be concealed under access panels flush with cab top or bottom surfaces, respectively. A duplex plug receptacle shall be provided in the pit and on top and bottom of each car. The lighting fixtures and receptacles on exterior of car shall be controlled by a switch adjacent to each fixture.
    c. Provide 115 volt ac plug receptacle (GFCI) within 12 inches of CCTV camera location. Coordinate the installation of CCTV equipment within the design of the elevator cab as the Elevator Contractor is responsible for the installation of the camera and wiring to the control room.
15. Car Doors and Door Equipment
    a. Car doors and door frames shall be suitably reinforced and provided with a laminated stainless steel #4 finish on cab side and baked enamel finish on hoistway side. Doors shall protect the full width and height of car entrance opening when in the fully closed position. Car door frames shall be integral with front wall of cab.
    b. Hanger cover plate sections above the door opening shall be removable from the hoistway. Doors shall be guided at the bottom by composition gibs engaging threshold grooves with minimum clearance.
    c. Car/Hoistway Door Operator: Car and hoistway doors at each landing shall be opened and closed quietly and smoothly by a direct current electric operator.

d. Door operation automatic at each landing with door opening being initiated as car arrives at landing and closing taking place after expiration of specified time interval, with electric contact to prevent starting elevator away from landing unless car door is in its fully closed position.

1) Time door closing to start 5 seconds minimum from notification that car is answering landing call.

2) Time doors to remain open five seconds minimum.

3) Time shall be adjustable to 20 seconds.

4) The interval of time that the doors remain open at intermediate landings shall be less for a stop made in response to a landing call. Door open time at a dispatching terminal shall be longer than the time for a stop in response to an intermediate landing call.

5) All door timers shall be adjustable from the controller display panel.

16. Capacity Plate:

1) The car capacity plate shall be of plain stainless steel and, in addition to data required by the ASME Code, but shall not bear the name of elevator manufacturer.

17. Door Operator Equipment

1) Provide a water resistant heavy-duty GAL MOVFR or ELES Engineering approved equal door operator with encoderless VVVF drive. Closed loop door operator designed to operate car and hoistway doors simultaneously at the speed specified. Door shall open automatically when car stops at landing to discharge passengers or to answer valid calls and close automatically after predetermined time interval has elapsed. The doors shall be capable of smooth and quiet operation without slam or shock. Door operator to have the following features:

a) One half (½ HP) horsepower motor and heavy-duty sprocket, chain, belt, and sheaves.

b) Closed-loop regulated speed performance.

c) Hand-held keypad programming.

d) Adjustments can be stored in the keypad and downloaded to another operator.

e) Adjustable door obstruction reversal.

f) Optical cams with LED indicators.

g) Test switches for open, close, nudging, and speed zone set up.

h) Universal inputs for open, close, and nudging.

i) Reversing switch to back up the door reversal device.

j) Designed for interior and exterior applications.

2) Provide a non-contact door reversal device with light immunity: The Door Reopening Device shall cause both the car and hoistway doors to reverse, should they detect an obstruction in the elevator entrance. The device electrical wiring shall be supplied with quick disconnects terminals to facilitate replacement. The infrared curtain detector shall include the following:

a) A protective infrared detector field extending from 1 1/2" above the car sill to a height of 68".

b) A fail-safe control system to prevent the doors from closing in case of power loss to the detector.

c) A one-piece full door height protective lens cover designed to be completely waterproof and to withstand impact, abrasion and vandalism.

I. Normal and final terminal stopping devices shall be provided for elevator conforming to the ASME Code requirements.

1. Final terminal stopping devices, located in hoistway or on the car and operated by cams, shall be fitted with rollers having a rubber or other approved composition tread to provide silent operation when actuated by the cam.

2. Normal terminal stopping device may be mounted in hoistway, on top of the car, or in the machine room.

J. Signal Devices and Fixtures

1. Car Operating Panel

a. Provide one (1) main panel in the front and one (1) auxiliary panel. The COP shall be a vertical type.

2. General: Provide signal fixtures and control devices for each elevator. Buttons and signals shall be tamper resistant of the illuminated type that light-up when activated and remain lit until call or other function has been fulfilled. All signal fixture and control device faceplates shall be of Type 316L, nominal 0.135 inch thick stainless steel with No. 4 finish, unless otherwise shown on the Contract Drawings.

3. Car operating panels shall contain Braille plates adjacent to each call button. Contractor to coordinate proper landing call outs based on maximum characters as indicated on Contract drawings. Buttons for DOOR-OPEN, DOOR-CLOSE, ALARM, EMERGENCY PHONE call functions are to be supplied. Buttons are to be vandal-resistant and of the positive stop type.

4. Car Operating Panel shall have a locked service cabinet for keyed switches of the car light; exhaust fan, independent operation, GFI duplex outlet as indicated on the Contract drawings. The service cabinet key shall be EPCO-1 security switch.

5. Provide Emergency Communication: "Hands-free" ADA compliant telephone/intercom.

6. Hall Station: Riser of hall stations of the push-button, call acknowledging, stainless steel, tamper resistant type shall be mounted at all elevator landings. Highest landing shall have a single DOWN button. Lowest landing shall have a single UP button. Incorporate ADA compliant telephone with each hall station. Braille Indicator Plate shall be provided. Faceplate finish shall be Type 316L stainless steel #4 finish unless located on a below ground station whereby Bronze (or anodized aluminum) cladding shall be used. The Hall Station shall be flush to the surface and shall not be projected out.

7. Hall Lanterns:

a. Tamper-resistant hall lanterns shall be equipped with illuminated (LED type) UP and DOWN signal arrows, but provide single arrow where only one direction is possible. Provided units

projecting from faceplate for ease of angular viewing. Match materials, finishes and mounting method with hall stations.

8. In conjunction with each hall lantern, provide an adjustable electronic chime signal to indicate that a car is arriving in response to a hall call and to indicate direction of car travel. Signal shall sound one for up direction of travel and twice for down direction.

4. Bell Alarm System: Bell alarm system for each elevator shall be properly located within building and audible outside hoistway when activated by the EMERGENCY ALARM call button on each car control building/station. When the emergency stop switch is activated inside fire service box, the bell alarm system should not be activated.

5. Firefighters' Service System: Firefighters' service system shall be provided in compliance with Code requirements.

K. Drip pans constructed of 26 USSG galvanized sheet steel shall be provided below all bearings to catch lubricant drippings, except for bearings that are fitted with effective approved grease seals.

L. Metal parts visible to the public shall be field painted.

M. A complete set of special tools or wrenches that are designed specifically for tasks associated with elevator inspection, maintenance and repair shall be provided with a case or suitably mounted in the storage cabinet.

N. At the expiration of the warranty requirements, the Contractor shall provide a spare parts and service facility in the United States at no additional cost to the Authority from which all manufactured parts and components of the equipment furnished and installed can be obtained for an additional three years.

O. Machine Room Equipment:

Machine room shall be 224 sq. ft. minimum for a single elevator.

1. Machine Room Emergency Lighting: Maintained Emergency lighting fittings shall be provided in each elevator machine room.

   a. There shall be a minimum of one maintained lighting fixture.

2. Clearance around equipment in each machine room shall comply with provisions of all applicable codes. Clear distance for the maintenance purposes shall be at least eighteen (18") inches. In no case shall this clearance supersede minimum Code requirements.

3. Equipment in elevator machine room shall be so arranged that replaceable items can be removed for repair or replacement either by overhead hoist and dolly, or other conventional means, without dismantling or removing other equipment components in the same machine room.

4. Machine rooms must be air conditioned and heated to maintain an ambient temperature of 50^0 F to 80^0 F degrees and a relative humidity between 35% and 50%. The air conditioner shall be a Split System. The heating system for the machine room is also a built in system. A forced removal should be done by moving the air from the room to the outside of the building to another part of the building to keep an air exchange through the equipment room. Intake and exhaust vents should not be located close to each other.

5. Any component attached to the controller shall have a minimum clearance of eighteen (18") inches from the side(s) of the component requiring access for maintenance and free air circulation.

6. One set of approved electrical and hydraulic diagrams of elevator shall be mounted in an aluminum channel frame with Lucite cover and waterproof fiberglass backing and installed adjacent to the appropriate drive machine.

7. Provide Mats of insulating rubber or other suitable floor insulation in the front of the Controllers.

a. The Resistance range shall be $1x10^4<1x10^6$ and shall meet ANSI/ESD requirements.

b. The rubber mat shall be the width of the controller plus twelve (12") inches.

c. The length of rubber mat shall be a minimum of twenty four (24") inches.

d. The rubber mat shall be one quarter (¼") inches thickness and beveled at each end.

2.04 KIOSK SURVEILLANCE CONTROL AND COMMUNICATION

A. Surveillance Camera Provisions (Surface Elevators). All requirements for CCTV shall comply with the WMATA SMNT Department.

1. Space provisions and mounting holes shall be provided for closed-circuit television (CCTV) cameras to be furnished and install by CCTV Sub-contractor.

    a. The Contractor shall coordinate with the CCTV Sub-contractor and install wiring from the CCTV location within the elevator cab to an interface terminal and video transmitter located on the elevator car. Final equipment selection has not been performed and is subject to change. Coordinate model, configuration, and location with the CCTV Sub-contractor.

        1) Power will be required by the video transmitter and CCTV camera and shall be provided.

        2) Equipment: Fiber Optic Video Transmitters (Elevator Cameras)

            a) The Contractor shall work with the CCTV Sub-contractor to install CCTV Sub-contractor-provided fiber-optic cable.

            b) The transmitter to a terminal location shall be specified by the CCTV Sub-contractor. The Contractor shall tag the cables appropriately, indicating that they are for future use by others.

B. Supply the following status indication, control, and communication functions for each elevator car and landing at an annunciator panel in the kiosk: indication, control, and communication functions in each elevator and landing; and all interconnecting wiring required to provide a complete and operable system. Systems to be provided and installed include the following:

1. Kiosk annunciator panel: Panel shall be a single panel approximately 7-½ by 19 inches. Coordinate design to ensure that the panel is compatible with the mounting provisions, previous designs, and human factors. The panels shall contain:

    a. Indicators:

        1) Visual display of elevator car status, to include landing stopped at or being approached and direction of travel:

            a) Designate elevator by functional name, e.g., Garage 1.

            b) For garage elevators designate landing by garage floor level.

        2) Out of service because of malfunction.

        3) In-Car stop switch is actuated.

        4) Continuous audible alarm activated when emergency alarm switch in car is anitiated.

        5) Indicator lamps shall be LEDs, with life expectancy of 50,000 average rated hours.

2. Controls:

        1) Out of service.

        2) Override control.

        3) Door open.

4) Landing selection.

5) Push-button switches shall have limited over-travel to prevent damage due to abuse and shall be equipped with lift-up covers to avoid inadvertent operation, have mechanical and electrical life of 25,000 cycles, with integral or isolated illumination circuit and be normally open with momentary action or alternate action circuitry.

6) When the override control switch is OFF, the kiosk controls shall function in parallel with the car and landing controls, i.e., the selective/collective control system shall respond to a kiosk-initiated landing selection with the normal priority afforded the remaining system landing selection and call buttons.

7) When the override control switch is ON, the following actions shall take place:

   a) If the car is stationary at a landing, it shall remain at the landing and the doors if opened, shall close and remain closed.

   b) If the car is in motion, it shall stop at the first landing reached and the doors shall remain closed.

   c) The elevator control system shall then respond only to the kiosk controls and car staton.

   d) The car shall park at the designate landing.

8) When the OUT OF SERVICE switch is actuated, the elevator shall return to the lowest landing before shutting off.

3. Elevator fire detection sensor: Provide space and mounting holes for smoke and fire detection sensors to be furnished and installed as required by building, electrical, elevator, and local codes. Install wiring from the sensor location in the car to interface terminal cabinet in the machine room, for connection from the sensors to the smoke and fire detection system. Coordinate with installers to allow installation of sensors and operational checkout of the system.

4. Passenger - Kiosk communications VOIP system:

   a. Communications signal button in elevator car momentary contact to illuminate back-lighted signal button in car and latch on a continuous audible signal and illuminated indicator in the kiosk.

5. Communications buttons at landings, momentary contact, to illuminate back lighted signal button at the landing and latch on a continuous audible signal and illuminated indicator in the kiosk.

6. Push button in kiosk to activate intercom system and reset indicator lamps and audible alarm.

7. Each passenger operated device shall have identification markings as specified for car operating devices.

8. The voice communication intercom system shall function as a master remote network. The master station shall be located in the kiosk annunciator panel and shall include a speaker-microphone, audio amplifier, on-off indicator lamp, audible signal device control and push button lamp for the operations. A remote station shall include a speaker-microphone and a communications signal button shall light the signal button and cause a continuous audible signal at the master station and light indicator lamp corresponding to the calling remote station. Communications between master and remote station shall be established upon the actuation of the master station push-button control corresponding to the calling remote station with the master station push-to-talk control determining the direction of transmission.

9. If successive calls are received from other remote stations while communication is in progress with one remote station, the audible signal shall sound the indicator lamps corresponding to the calling remote stations shall light and both shall remain on the indicate waiting calls.

10. Means shall be provided to clear the indicating lamps independently. Communication initiated from the master station shall be established upon actuation of the push button control corresponding to the called remote station, with the master station push-to-talk control determining the direction of transmission.

11. The audio amplifier at the master station shall be all solid state in construction and shall control incoming and outgoing volumes for all of the remote stations. The volume levels shall be preset during installation and shall be adjustable to provide a maximum of five watts rms at the speaker-microphones.
12. The power supply shall supply all ac and dc voltages necessary for all circuitry associated with the voice communications intercom system, and shall operate from the 120 VAC, 60 Hertz emergency power supply located in the elevator machine room.
13. The audio amplifier and the speaker-microphones shall have a frequency response of plus or minus three Db from 300 Hertz to 5,000 Hertz. Power consumption shall be five (5W) watts maximum in standby and fifty (50W) watts maximum under load.
14. The Contractor shall be responsible for shielding, grounding, and other measures necessary to protect the voice communications intercom system from interference from other electrical systems.
15. Speaker grilles shall have a minimum of thirty five (35%) percent open area over the entire surface of the speaker cone.
16. Switches and relays used with this system shall have an operating life exceeding 5,000,000 cycles. Documentation shall be provided by the Contractor to the Engineer, for his approval, to substantiate this life cycle level.
17. The system shall perform adequately, as approved by the Engineer, with both the remote and the master station test personnel speaking from three feet away from the speaker-microphones.
18. Communication in the car shall also rollover to a 24-hour manned site (Rail Operations Control Center) in the event that the kiosk does not respond to the call.
19. Each passenger-operated device shall be identified in accordance with ADA/ADAAG requirements.
20. ADA requirement for providing emergency two-way communications between an elevator and a point outside the hoistway (the Kiosk).
21. Device mounting heights shall comply with:
    a. ADAAG requirements.
22. ASME A17.1 The highest operable part of the two-way communication system shall be a maximum of forty eight (48”) inches from the floor.
23. A Braille Instruction Plate shall be permanently affixed on each remote intercom unit.
    a. ADA Standards: Raised symbol and lettering (Signage) located adjacent to the device.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to beginning installation of elevator equipment, examine the following and verify that no irregularities exist that would affect quality or execution of work as specified.

1. Hoistway size and plumbness.
2. Sill pockets.
3. Anchor brackets
4. Sill supports.
5. Spreader/Divided beams.
6. Machine beams and any other supplied by others.
7. Pit Depth
8. Overhead clearance

B. Do not proceed with installation until previous work conforms to project requirements.

3.02 INSTALLATION

A. Electrical Installation

1. The Contractor shall install all raceways and wiring necessary for the proper connection and operation of all equipment. The installation shall comply with the applicable requirements of the NEC and local codes.
2. Raceway
    a. Rigid conduit connecting the various items of elevator equipment and electrical boxes in the machine room and hoistway shall be run parallel to the ceilings and walls. Metal wireway and auxiliary gutters in the machine room shall run exposed in readily accessible locations and shall not protrude into the working space around equipment.
3. Liquid-tight flexible conduit shall be used for connections to motor, limit switch, interlock push-button box, door operator motor, and similar devices. A length of liquid-tight flexible conduit 18 to 24 inches long shall be used for connection to the elevator drive motor.
4. Raceway terminal fittings shall be free from burrs, shoulders, or other projections that will reduce internal passage area or cause abrasion of conductors.
5. Electrical boxes shall be installed in accordance with the requirements of NEC paragraph 370.
6. Wiring
    a. All wiring shall be run in conduit, metal wireway, or auxiliary gutter, with the following exceptions:
    b. Flexible hard-service cord, type SO, used between fixed car wiring and switches on car doors.
    c. The traveling cable connection to the elevator car.
    d. Wire and cable shall be sized for their respective duty so that the maximum current carried shall not exceed limits prescribed by the NEC and local codes. The minimum sizes of conductor shall be 12 AWG for lighting and receptacle circuits and 16 AWG for operating, control and signal circuits, except for traveling cable, where 14 AWG shall be the minimum size for elevator lighting circuit conductors.

e. In glass hoistways, wiring shall be installed only in the locations shown with the requirement that wiring and conduit be hidden from public view.

f. The traveling cable shall run from a junction box on the bottom of car to a junction box approximately midway in the hoistway. The cable shall be anchored and suspended to minimize any strain on individual cable conductors. The cable shall be free from contact with the hoistway construction, car, or other equipment. The overall covering of cable shall remain intact between junction boxes. The Contractor shall ensure that the cable shall not bend to a radius less than twelve (12) times the outer diameter at any position of elevator travel.

g. Traveling cable shall be suspended by the wire rope center or self-gripping devices where cable weight will not cause excessive crushing forces.

7. Splices and terminations of conductors shall be made only in outlet, junction. Splices in conduit or raceways will not be permitted. Splices and terminal connections shall be made only by means of solderless connectors and terminal lugs as specified. Splices shall be covered with electrical insulating tape to an insulation level equivalent to that of the conductors. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.

8. Grounding

a. The Contractor shall be responsible for grounding and bonding all parts of the elevator metallic structure, equipment and raceway in accordance with the applicable requirements of the NEC and the codes and regulations of the jurisdictional authorities. An equipment grounding conductor will be furnished and installed by other trades in each feeder to the elevator machine room and terminated in a disconnect device or junction box.

9. The Contractor shall provide equipment grounding conductors from the disconnect devices or junction boxes for all feeders and branch circuits as shown and required. Electrical equipment shall be provided with a minimum of two ground paths. One path shall be a green insulated equipment grounding conductor. The second path shall be a connection to grounded metallic structure using metallic fasteners, metallic conduit and/or bonding jumper. In the elevator car, bond exposed metallic structures, ac equipment enclosures and lighting fixtures to grounded elevator metallic structure with metallic fasteners as shown.

10. Each device, each terminal, and each wire on the controller panels shall be properly identified by name, letter, or standard symbol in an approved indelible manner, on the device, panel, or wire. The identification markings shall be identical to markings used on the wiring diagrams.

B. Hydraulic Elevator Cylinder

1. The Contractor shall set the hydraulic elevator cylinders true and plumb.

a. Dielectric Insulation Installation

b. Each cylinder shall be electrically isolated from the building steel and other earth ground sources.

c. The following are minimum requirements:

a. Install an insulating gasket between the platen plate and floor of the elevator cab. Use insulating sleeves and washers on the bolts.

b. Use insulating pads to insulate the cylinder support members (channels) from the guide rails and other structures at ground potential.

c. Use insulating sleeves and washers on the bolts that connect the cylinder to the support channels.

d. Install an insulating coupling on the oil supply line between the pump and cylinder, located as close to the cylinder as possible.

e. Insulating gaskets shall be installed in the same manner as a normal gasket.

a. Sleeves shall not be forced through misaligned bolt holes. Where misalignment occurs, the holes shall be reamed true, and all metal, chips shall be carefully removed.

b. The sleeves shall extend into the plastic washer on both sides of the flange. Any sleeves or washer cracked during installation shall be replaced immediately.

c. After making up the flange, the resistance of each bolt to the flange shall be tested using a 500-volt megohmmeter. If the resistance of any bolt is less than 50 megohms, the sleeve and washer shall be checked and changed, if necessary, to provide the required resistance.

3.03 DEMONSTRATION

A. Acceptance Tests

1. The Contractor shall submit an operational test plan to the Authority for approval. When each elevator, furnished, installed, and tested, is ready to be placed in interim service, the Contractor, at no additional cost to the Authority, shall perform operational tests described below.

2. Notification Requirements: Notify the Project Manager and ELES Engineer a minimum of five (5) working days prior to each scheduled test so that arrangements can be made for the presence of appropriate personnel to witness the tests.

3. Acceptance Tests and inspections will be based upon the elevator meeting the requirements of the Specification and as evidenced by the operational test shall be witnessed by WMATA representative.

B. Elevator Tests

1. When the elevator work is fully completed, the Contractor shall demonstrate to the satisfaction of the Authority and Authorities Having Jurisdiction that the proper operation of every part of the equipment complies with all applicable requirements including the ASME Code.

a. The inspection procedure outlined in the ASME A17.2 will form a part of the final inspection.

b. No shop test of elevator motor and no certified test sheets will be required.

c. The heating, insulation, and resistance of the motors will be determined under actual conditions after installation.

d. The Elevator Contractor shall furnish all test instruments and materials, required at the time of final inspection, to determine compliance of the work with the Contract requirements. Materials and instruments furnished shall include standard 50-pound test weights, megohmmeter, voltmeter and ammeter, Centigrade calibrated thermometers, spirit level, and stop watch. At the time of final inspection, tests shall include, but not be limited to, the following:

a. After installation, each elevator shall be tested without load by the Contractor. The elevator shall be subjected to a test for a period of eight-hours continuous run. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.

b. Full-Load Run Test

a. The elevator shall be subjected to a test for a period of one-hours continuous run, with full specified rated load in the car. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of ten (10) seconds at each landing.

b. Speed Test

a. The actual speed of the elevator car shall be determined in both directions of travel, with full specified rated load and with no load in the elevator car.

b. Speed tests shall be made before and after the full-load run test.

c. For hydraulic elevators, speed shall be determined with a temporarily mounted tachometer on the guide rail or stop.

d. Car speed when ascending shall be not more than ten (10%) percent above not more than 10 percent below the specified car speed.

e. Car speed when descending shall be not more than twenty five (25%) percent above not more than ten (10%) percent below the specified car speed.

f. Temperature Rise Test

The temperature rise of the drive unit motor shall be determined during the full-load test run. Temperatures shall be measured as specified in NEMA and IEEE Standards. Under these conditions the temperature rise of the motor shall not exceed NEMA and IEEE specified temperature rise. Test shall be started only when all parts of equipment are within 9°F of the ambient temperature at time of starting test.

g. Car Leveling Test

Elevator car leveling devices shall be tested for one quarter (¼") inches accuracy of landing at all floors with no load in car and with full load in car, in both directions of travel.

One re-level operation is permitted when full load is in the car.

Accuracy of floor leveling shall be determined both before and after the full-load run test.

h. Insulation Resistance Test

The complete wiring system of elevator shall be free from short circuits and accidental grounds. The insulation resistance of the system shall be more than one megohm when tested by using a 500-volt megohmmeter. The elevator structure, equipment, and raceway shall be tested for continuity to ground

3.04 PREPARATION

A. Elevator Protection

1. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.
2. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.
3. Protection: During installation and until all elevator systems are fully operational and accepted by WMATA, make all necessary provisions to protect all elevator components from damage, deterioration, and adverse environmental conditions. Do not use or allow the use of the elevator for construction purposes such as hauling materials or worker transport during construction.
4. Install hooks and provide the protection pads into the elevator cab to prevent any damage or deterioration.
5. Field Painting:
   a. The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust-inhibiting paint.
6. Metal parts visible to the public shall be field painted where specifically shown or authorized by the Authority.

3.05 MAINTENANCE SERVICE

A. The Contractor shall perform full maintenance service for a period of two years on each elevator in accordance with the manufacturer's maintenance manual and WMATA ELES maintenance program prior to WMATA providing permanent maintenance. The period of maintenance shall begin after test(s) and Provisional Acceptance of each elevator and shall extend to the scheduled date of Final Acceptance for all units in the same facility plus a period of two years. In no case shall the interval between inspections and testing be greater than one month. The maintenance service during the warranty period shall be provided by fully trained elevator mechanics. The maintenance tasks shall include, but not be limited to, the following:

1. Inspection of completed installation and periodic testing tomaintain the elevators in completely operable condition.
2. Contractor shall provide support for periodic, accident and incident, PM compliance inspections.
3. Lubrication of parts and the protection of the equipment.
4. Replacement of defective parts at no additional cost to the Authority.
5. Annual clean-down of the elevator and hoistway enclosure is required. Make necessary arrangements with Authority in order to minimize any inconvenience.
6. Contractors performing maintenance are responsible for all service, repair work, and emergency calls. The Contractors shall provide unlimited service during revenue hours and twenty-four (24) hour (including Holidays) emergency call back service at no additional cost.
7. Provide twenty (24) hour (including Holidays) emergency service during the maintenance period consisting of a prompt response (within 1 hour) to emergency request by telephone or otherwise from Authority or designated representative if an elevator is inoperable or in case of injury, entrapment, or potential injury to persons.
8. Unlimited service callbacks are included with a required response time of one (1) hour (including Holidays).
9. Periodic maintenance (based on WMATA schedule) shall be performed off peak hours to minimize service interruption as long as the other elevator serving the same plateform is operational.
10. Reporting: Detailed monthly records of tasks performed including names of individuals performing the tasks, date and time performed, and other pertinent data. In addition, the reports are to be provided in an electronic format acceptable to WMATA’s needs.
11. Contractor performed maintenance shall follow the WMATA Office of Elevator and Escalator Operations procedures, schedules and check charts.
12. Within three (3) months prior to the termination of this contract, the Authority or his designated representative(s) shall make a thorough maintenance inspection of all equipment covered under this contract. The Contractor shall provide personnel to remove, test, and operate equipment as necessary. All deficiencies found as a result of inspection shall be corrected by the Contractor as required in this agreement with no additional cost for the Authority.

3.06 REMOTE MONITORING SPECIFICATIONS

A. Allen Bradley DF1 or ELES Engineering approved equal or industry standard Modbus protocol shall be provided to transmit data from the Elevator/Escalators controller to the Authority’s AEMS RTU computer control and data system. The Design-Builder shall provide a controller data interface to a DH485 network located in the Elevator /Escalator machine room. The DH485 controller interface shall be programmable for data rates up to 115Kbps. The interface shall allow other nodes such as other Elevator or Escalators to be readily incorporated into the DH485 network. The controller data interface shall include one Allen Bradley SLC PLC per station to function as a data concentrator to consolidate data from all the controllers in the station. The software for the data concentrator shall be as specified

by the Authority. The data concentrator shall receive controller data over the DH485 data network and provide formatted data to the AEMS RTU through a RS 232 link. This data transmission may be accomplished by a separate PLC controller integrated into the control system.

B. The Elevator /Escalator control system shall automatically initiate the transmittal of data when data is requested by the Authority's AEMS system and continue until all data is received by the AEMS RTU in the station AC switchboard room. The Authority will perform final integration of the data in the AEMS system.

C. The Contractor shall also provide the required hardware to download data from any fault finding annunciator panel to a supplied laptop PC being utilized at the Elevator/Escalator location. The provided software shall permit the downloading and storage of data on the supplied laptop PC from multiple fault finding annunciator panels.

D. The Contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC or approved alternative) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network.

1. The Contractor shall provide all wiring and programming of the PLC to communicate with station data concentrators on the DH485 network. Coordinate work with WMATA ELES Engineering.
2. The Contractor shall pull all remote monitoring cables to the interface in the elevator controller from the remote monitoring network going back to WMATA's Automated Energy Management System (AEMS) remote terminal unit (RTU).
3. Provide Ethernet communication between the elevator machine room and WMATA's communication room. The communication port shall be located less than six (6') feet from the controller and shall have minimum of two (2) ports for data communication.

E. Terms and Definitions

1. Boolean - A single bit data type.
2. DF1 - A Rockwell Automation Company proprietary communications protocol.
3. DH485 - An industrial communications network used by Allen Bradley programmable controllers.
4. Integer - A data type 16 bit signed (range -32768 to 32767).
5. PLC - Programmable Logic Controller.
6. QEI - QEI Inc. Springfield NJ.
7. RTU - Remote Terminal Unit.

F. Elevator Remote Monitoring Data Specification

1. Overview

a. The design of the WMATA escalator and elevator monitoring system shall include a data concentrator PLC to gather data from the elevator control PLC's over an Allen Bradley DH485 network or ELES Engineering approved equal. The QEI RTU shall read data from the WMATA data concentrator PLC via an RS 232 serial connection to a 1746-BAST (or ELES Engineering approved equal) module using Allen Bradley DF1 (or ELES Engineering approved equal) protocol. See Figure 1.1 for reference. This specification defines data to be presented by the WMATA data concentrator PLC to the QEI RTU. The WMATA data concentrator PLC station shall pole the escalator and elevator controller(s) periodically for data and format the data into blocks within the WMATA data concentrator. An Ethernet TCP/IP connection is available at the Data concentrator PLC. The data concentrator PLC has been designed to collect data from up to (10) escalators and/or elevators. The data concentrator PLC is to be mounted into the

existing QEI RTU enclosures and powered by a 120 VAC source from within the RTU. For Metro stations where more than (10) escalators and elevators are present additional data concentrator PLC's will be required.

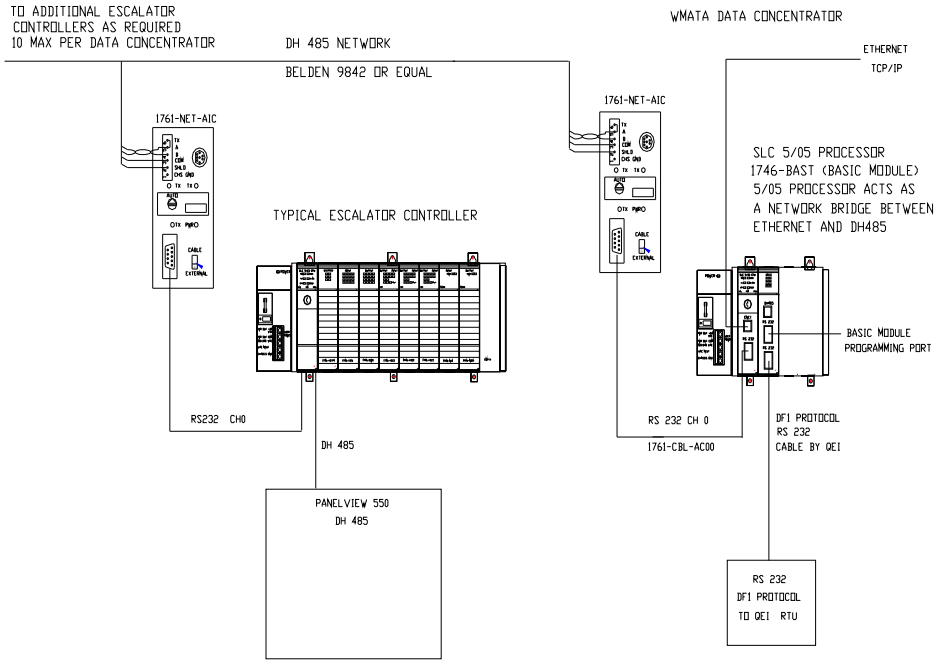


Figure 1.1 WMATA Escalator and Elevator Monitoring System

2. Data Concentrator PLC Data File Assignments.
   a. The WMATA data concentrator PLC shall store data for up to (10) escalators and/or elevators in any combination as defined in Table 2.1.

Table 2.1 Data Concentrator PLC Data File Assignments

Escalator DH485 Node #	Elevator DH485 Node #	Status Bits File	Analog Data File	DC PLC MSG File No.	DC PLC MSG Buffer File No.
1		N20	N21	N81	N101
2		N22	N23	N82	N102
3		N24	N25	N83	N103
4		N26	N27	N84	N104
5		N28	N29	N85	N105
6		N30	N31	N86	N106
7		N32	N33	N87	N107
8		N34	N35	N88	N108
9		N36	N37	N89	N109
10		N38	N39	N90	N110
	11	N40	N41	N121	N141
	12	N42	N43	N122	N142
	13	N44	N45	N123	N143
	14	N46	N47	N124	N144
	15	N48	N49	N125	N145
	16	N50	N51	N126	N146
17		N52	N53	N127	N147
18		N54	N55	N128	N148
19		N56	N57	N129	N149
20		N58	N59	N130	N150
Data Concentrator PLC (DC)	25	N80	N79		

Each data file shall begin with word 1 (example: escalator #1 status bits begin with N20:1 and end at N20:20).

The data concentrator PLC communication ports shall be configured as follows:

Channel: 1
Driver: Ethernet
IP Address: TBD
Subnet Mask: TBD
Gateway Address: TBD

Channel: 2
Driver: DH485
Baud Rate: 19.2K

Node Address: 25

1756-BAST basic module communication ports shall be configured as follows:

Port 1: Programming port
Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

Port 2: DF1 port
Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

DF1 – Op Code 19 (Full Duplex, NHS, ER, Enable DPD, CRC error checking,
Timeout = 50
Retries = 3
RTS on delay = 20 msec
RTS off delay = 20 msec
Module address = 10

DH485 Port – Not Available

1. Data Format
    a. Data Concentrator status in File N80 per Table 3.0

Table 3.0 Data Concentrator Status Bits

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	BOOLEAN	Spare		
	1	BOOLEAN	Data Concentrator PLC Battery Status	FAULT	NORMAL
	2	BOOLEAN	Data Concentrator Basic Module Battery Status	FAULT	NORMAL
	3	BOOLEAN			
	4	BOOLEAN			
	5	BOOLEAN			
	6	BOOLEAN			
	7	BOOLEAN			
	8	BOOLEAN			
	9	BOOLEAN			
	10	BOOLEAN			
	11	BOOLEAN			
	12	BOOLEAN			
	13	BOOLEAN			
	14	BOOLEAN			
	15	BOOLEAN			
2		BYTE	Data Concentrator checksum byte1		
3		BYTE	Data Concentrator checksum byte2		

Words 4 through 20 of the Data Concentrator status file (N80) are unused.

The Data Concentrator Analog data file (N79) is unused.

2. Elevator data

   a. Two 20 word (40 BYTE) blocks of data shall be developed for each elevator one block for status bits and one block for analog data. Table 3.3 defines the format of data for status bits. Table 3.4 defines the format for analog data.

Table 3.3 Elevator Status Bits

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	FAULT	24 VDC POWER SUPPLY	FAULT	NORMAL
	1	FAULT	SAFETY CIRCUIT GOOD	FAULT	NORMAL
	2	FAULT	TOP FINAL LIMIT TRIPPED	FAULT	NORMAL
	3	FAULT	BOTTOM FINAL LIMIT TRIPPED	FAULT	NORMAL
	4	FAULT	DRIVE FAULTED	FAULT	NORMAL
	5	FAULT	OVERLOAD TRIPPED	FAULT	NORMAL
	6	FAULT	STOP BUTTON ACTIVATED	FAULT	NORMAL
	7	STATUS	IN-CAR ALARM BUTTON PRESSED	ALARM	NORMAL
	8	FAULT	OUT OF SERVICE BY DELAY	FAULT	NORMAL
	9	FAULT	MOTOR LIMIT TIMER TRIPPED	FAULT	NORMAL
	10	FAULT	VALVE LIMIT TIMER TRIPPED	FAULT	NORMAL
	11	STATUS	INSPECTION OPERATION ON	ON	OFF
	12	STATUS	INDEPENDENT SERVICE ON	ON	OFF
	13	STATUS	VISCOSITY CONTROL ON	ON	OFF
	14	STATUS	CONTROLLER TEST SWITCH ON	ON	OFF
	15	STATUS	FIRE SERVICE PHASE 1 ON	ON	OFF
2	0	STATUS	FIRE SERVICE PHASE 2 ON	ON	OFF
	1	FAULT	SMOKE SENSOR @ MAIN ON	ON	OFF
	2	FAULT	SMOKE SENSOR @ OTHERS ON	ON	OFF
	3	STATUS	EMERGENCY POWER OPERATION	ON	OFF
	4	STATUS	OVERRIDE ON	ON	OFF
	5	STATUS	CAR IS RUNNING UP	NOT-RUN	RUNNING
	6	STATUS	CAR IS RUNNING DOWN	NOT-RUN	RUNNING
	7	STATUS	BRAKE LIFTED	LIFTED	NORMAL

	8	STATUS	CAR IS IN DOOR ZONE	NOT IN ZONE	IN ZONE
	9	STATUS	INTERLOCKS ARE MADE	OPEN	NORMAL
	10	STATUS	FRONT DOOR GATE SWITCH MADE	OPEN	NORMAL
	11	STATUS	FRONT DOOR FULLY CLOSED	OPEN	CLOSED
	12	STATUS	FRONT DOOR FULLY OPEN	CLOSED	OPEN
	13	STATUS	FRONT DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	14	STATUS	FRONT DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	15	STATUS	REAR DOOR GATE SWITCH MADE	OPEN	NORMAL
3	0	STATUS	REAR DOOR FULLY CLOSED	OPEN	CLOSED
	1	STATUS	REAR DOOR FULLY OPEN	CLOSED	OPEN
	2	STATUS	REAR DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	3	STATUS	REAR DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	4	FAULT	DOOR REVERSAL DEVICE FAILURE	FAULT	NORMAL
	5	FAULT	ROPE BRAKE SET	FAULT	NORMAL
	6	FAULT	LEVELING SYSTEM FAILURE	FAULT	NORMAL
	7	FAULT	WATER INTRUSION ALARM ACTIVE	FAULT	NORMAL
	8	STATUS	ELEVATOR SLC 5/03 LOW BATTERY	FAULT	NORMAL
	9	STATUS	ELEVATOR SLC 5/03 COMM. ACTIVE	FAULT	NORMAL
	10	STATUS	ELEVATOR SLC 5/03 LOCAL/REMOTE	REMOTE	LOCAL
	11	STATUS	ELEVATOR SLC 5/03 RUN/PROG	PROG	RUN
	12	FAULT	FAULTED	FAULT	NORMAL
	13	STATUS	OUT OF SERVICE	FAULT	NORMAL
	14		SPARE		
	15		SPARE		

4	0	STATUS	CAR POSITION 1	NOT AT POSITION	AT POSITION
	1	STATUS	CAR POSITION 2	NOT AT POSITION	AT POSITION
	2	STATUS	CAR POSITION 3	NOT AT POSITION	AT POSITION
	3	STATUS	CAR POSITION 4	NOT AT POSITION	AT POSITION
	4	STATUS	CAR POSITION 5	NOT AT POSITION	AT POSITION
	5	STATUS	CAR POSITION 6	NOT AT POSITION	AT POSITION
	6	STATUS	CAR POSITION 7	NOT AT POSITION	AT POSITION
	7	STATUS	CAR POSITION 8	NOT AT POSITION	AT POSITION
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				

Note: Words 5 through 20 are unused.

3. Elevator Analog Data
   a. Table 3.4 defines the format for analog data.

Table 3.4 Elevator Analog Data

WORD	DATA TYPE	MIN VALUE	MAX VALUE	UNITS	SCALE FACTOR	DESCRIPTION
1	INTEGER			AMPS	X10	DRIVE MOTOR AMPS
2	INTEGER			KWH	X1	PRE DAY KWH
3	INTEGER				X1	PRE DAY UP COUNT
4	INTEGER				X1	PRE DAY DOWN COUNT
5	INTEGER				X1	PRE DAY FRONT DOOR CYCLES
6	INTEGER				X1	FAULT CODE
7	INTEGER				X1	PRE DAY REAR DOOR CYCLES
8	INTEGER					
9	INTEGER					
10	INTEGER					
11	INTEGER					
12	INTEGER					
13	INTEGER					
14	INTEGER					
15	INTEGER					
16	INTEGER					
17	INTEGER					
18	INTEGER					
19	INTEGER					
20	INTEGER					

Note: All analog values are multiplied by 16 in the data concentrator to bit shift left 4 bits to align with QEI's 12 bit analog data types.

A note on communication loss: A 60 second watchdog timer is coded into each escalator file. If communications are lost between the data concentrator and the escalator controller for more than 60 seconds the watchdog timer will Timeout. When the timer has timed out the communications loss bit will be reset (0) to indicate the communications loss condition.

4. Time and Date Sync

a. The QEI RTU shall provide clock synchronization to the WMATA data concentrator PLC every 5 minutes. Table 4.1 defines the address and data format of the clock registers in the WMATA data concentrator PLC. The data concentrator PLC shall set the escalator controller date and time every day at 3 AM.

Table 4.1 Time and Date Sync

FUNCTION	ADDRESS	FORMAT
YEAR	N13:10	4 DIGITS
MONTH	N13:11	2 DIGITS
DAY	N13:12	2 DIGITS
HOUR	N13:13	2 DIGITS/24 HOUR
MINUTE	N13:14	2 DIGITS
SECOND	N13:15	2 DIGITS

5. Data Concentrator PLC Program
   a. The data concentrator PLC includes code to monitor up to 10 escalators and 5 elevators. Each escalators and elevators has an independent code file and a configuration bit. If an elevator is to be monitored the configuration bit must be set corresponding to the DH485 station address of the elevator controller. If the configuration bit is reset (0), the status and analog data table values for the elevator or escalator will be set to 0.
6. The configuration bits are as follows:

Configuration Bits

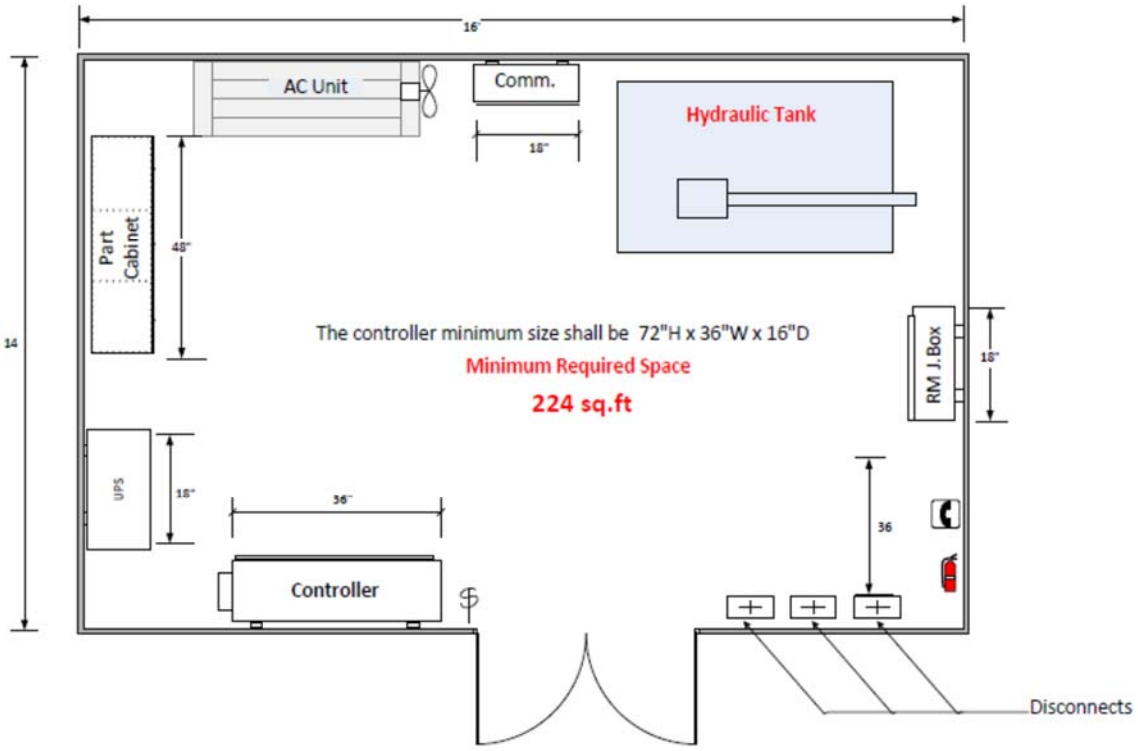
ESCALATOR CONFIGURATION BIT	DH485 ADDRESS OF ESCALATOR CONTROLLER	ELEVATOR CONFIGURATION BIT	DH485 ADDRESS OF ELEVATOR CONTROLLER
B9:0/1	1	B9:1/1	11
B9:0/2	2	B9:1/2	12
B9:0/3	3	B9:1/3	13
B9:0/4	4	B9:1/4	14
B9:0/5	5	B9:1/5	15
B9:0/6	6	B9:1/6	16
B9:0/7	7	B9:1/7	17
B9:0/8	8	B9:1/8	18
B9:0/9	9	B9:1/9	19
B9:0/10	10	B9:1/10	20

7. Data Concentrator Gateway IP addresses
    a. The Data concentrator PLC acts as a gateway between the Ethernet and DH485 networks. The PLC contains a list of IP addresses, known as the routing table which will be allowed access to the DH485 network.
    b. The routing Table will contain 20 addresses.

Data Concentrator IP Addresses

STATION	IP ADDRESS
1	TBD
2	TBD
3	TBD
4	TBD
5	TBD
6	TBD
7	TBD
8	TBD
9	TBD
10	TBD
11	TBD
12	TBD
13	TBD
14	TBD
15	TBD
16	TBD
17	TBD
18	TBD
19	TBD
20	TBD

3.07 EXHIBIT 1. HYDRAULIC SINGLE ELEVATOR MACHINE ROOM



END OF SECTION

SECTION 15070

VIBRATION ISOLATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing vibration isolation for mechanical equipment and piping.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities
   2. ASTM: A123.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Design for concrete inertia block and structural-steel bases. Include tabulation of design data on isolators including actual deflection; outside diameter; free, operating and solid heights of isolators; method of attachment; bolt sizes; and type and sizes of anchor plates.

B. Certification.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:
   1. Vibration isolators selected to produce uniform loading and deflection even when equipment weight is not evenly distributed; steel components hot-dip galvanized after fabrication in accordance with ASTM A123.
      a. Types of vibration isolators:
      b. For equipment and piping:
         1) Floor-mounted: Spring isolators.
         2) Ceiling-suspended: Suspension-type isolators.
   2. Spring isolators for floor-mounted equipment:
      a. Free-standing, laterally stable without housing, complete with minimum 1/4-inch thick neoprene, acoustical friction pad in series with spring element.
      b. Leveling bolts and adequate facilities for bolting to equipment and supporting structure using isolation washers.
      c. Coil outside diameter: Not less than 0.8 of operating height of spring.
      d. Horizontal stiffness: Not less than 0.8 of vertical stiffness.
      e. Springs designed to have additional 50-percent capacity beyond rated load.
      f. Springs designed so that ends remain parallel during and after spring deflection to operating height.
      g. Vibration isolators selected for lowest operating speed of equipment.
      h. Built-in adjustable limit stops with isolators provided for equipment of operating weight different from installed weights, to prevent rising of equipment when weight is removed and for equipment exposed to wind. Limit stops not to be in contact during normal operating conditions.

i. Welding of springs to load-plate assembly for vibration isolators with capacities of 6,000 pounds or less is prohibited.
j. Vibration isolators with capacities of 6,000 pounds or less are permitted use of cups or other positive means for restraining springs.

3. Suspension-type isolation hangers for ceiling-suspended equipment:
   a. Combination of spring and neoprene in series.
   b. Spring made of stable steel.
   c. Encased in structurally stable steel bracket.
   d. Spring diameter large enough to permit 15-degree angular misalignment of rod connecting hanger to equipment without rubbing on box
   e. Designed to provide complete support for suspended units upon failure or rupture of isolator.
4. Inertia bases:
   a. Furnished by vibration-isolator manufacturer.
   b. Complete with steel-reinforced concrete cast into welded structural-steel channel frame, mounting templates and brackets for vibration isolators with thickness equal to eight-percent minimum of longest base dimension.
   c. Structural-steel work: Section 05500.
5. Concrete equipment subbases (housekeeping pads)
   a. Concrete: Sections 03100, 03200 and 03300.
   b. Concrete subbases not less than four inches high provided for floor-mounted equipment. Subbases resting on structural floor and reinforced with steel rods interconnected with reinforcing bars of floor by means of tie bars hooked at both ends.
   c. Clearance between subbases and inertia bases: Two inches minimum.
   d. Subbase concrete: Class 2500, Finish No. 4.
6. Snubbers:
   a. As recommended by manufacturer of vibration isolator.
   b. Compatible with vibration isolators provided.

B. Isolation-Unit Types and Deflection:
1. Fans, ventilating units, evaporation units and air-conditioning units: Floor-mounted and ceiling-suspended.
   a. Spring isolators designed for a minimum of 1.5 inches deflection.
   b. Snubbers: Where shown.
2. Pumps:
   a. Base-mounted pumps on inertia bases.
   b. Inertia bases shaped to include base elbow supports for connected piping and at least 1-1/2 times weight of supported equipment or a minimum base thickness of eight percent of longest base dimension, whichever results in greater weight.
   c. Springs with minimum deflection of 1.5 inches under imposed static load.
3. Chillers:
   a. Vertically restrained spring isolators designed for 1.5 inches minimum deflection. Inertia bases if recommended by chiller manufacturer.
4. Self-contained air-conditioning units:
   a. Spring-isolators designed for a minimum of one-inch deflection except through-wall units.
5. Remote air-cooled condensing or condenser units:
   a. Isolators: As specified for self-contained units.
6. Cooling towers:
   a. Steel beams mounted on vertically restrained spring isolators designed for 1.5 inches minimum deflection.
   b. Rails: Acceptable, if performance requirements for spring isolators specified for cooling towers are met.

c. Height of steel beams designed to support loads and eight-percent minimum of longest span between isolators.

7. Air compressors:
   a. Temperature-control compressors: Spring isolators designed for 1.5 inches minimum deflection.
8. Piping:
   a. Ceiling-suspended piping: Combination spring and neoprene in shear element hangers as specified for ceiling-suspended equipment. Springs designed for 1.5-inch minimum deflection. First two isolation hangers of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
   b. Floor-mounted piping isolated by spring isolators with one-inch minimum static deflection. First two spring isolators of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
9. Grout: Section 03300, premixed shrinkage-compensating grout.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install vibration isolators where shown as recommended by the equipment manufacturer.

B. Mount mechanical equipment on vibration isolators to isolate equipment from structure.

C. Jack bases and equipment into position and wedge or block before vibration isolators are loaded.

D. Use isolator leveling bolts for final leveling of equipment after equipment is in operation.

E. Springs installed so that ends remain parallel during and after deflection to operating height.

F. Mount snubbers as close to vibration isolators as practicable.

G. Grout void between pump bases and inertia-base concrete.

H. Piping connected to equipment isolated from structures as follows:
   1. Condenser-water piping in its entirety.
   2. Chilled-water piping: Piping connected to equipment, mounted on vibration isolators or suspended with vibration hangers, isolated for a distance of 50 feet from equipment. Piping with installed length less than 50 feet isolated in its entirety only when connected to equipment provided with vibration isolators.
   3. Compressed-air piping: Connected to compressors for a distance of 50 feet from compressor. Piping with installed length less than 50 feet isolated in its entirety.

END OF SECTION

SECTION 15075

IDENTIFICATION OF MECHANICAL EQUIPMENT AND PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing nameplates and tags on mechanical equipment and apparatus.

B. Related Work Specified Elsewhere:
   1. Field painting: Section 09920.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Samples:
      a. Labels and tags in each size.
   2. Documentation:
      a. Charts for valves; include valve identification number, location and purpose.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Nameplates: Laminated plastic.

B. Tags: 18-gauge stainless steel.

C. Identification Plates: Bronze, Authority-furnished.

PART 3 - EXECUTION

3.01 IDENTIFICATION:

A. Equipment and Apparatus:
   1. Label equipment and apparatus with one-inch high white letters engraved on 1-1/2 inch high, black, laminated-plastic nameplates securely fastened to metal panels, showing function and unit number of item.
   2. Identify devices including transducers, controls and switches by means of 1/2-inch high white letters engraved on one-inch high, black, laminated plastic nameplates identifying manufacturer and function of equipment.
      a. Provide same type nameplates on front cover for each pilot light and for mode-of-operation selector switches. Label positions of mode-selector switches AUTOMATIC/OFF/EMERGENCY EXHAUST/EMERGENCY SUPPLY for subway-ventilation fans, and LOCAL/TRACK 1/LOCAL TRACK OFF/REMOTE for jet fans..
   3. Nameplates for components located in fan-control cabinets to show symbol used on schematic diagram to represent component. Label fan-control cabinet terminals using same symbols and identification corresponding to that shown on schematic diagram.

B. Piping:

1. Stencil legends and bands on piping showing service and direction of flow as specified in Section 09920.
2. Color coding of exposed piping and terminatings of piping is specified in Section 09920.

C. Valves:
1. Identify valves with 1-1/2 inch diameter, 18-gauge stainless-steel tags.
2. Designate appropriate service on each tag with 1/4-inch stamped black-filled letters and valve number with 1/2-inch stamped black-filled numbers.

D. Orifice Flange and Venturi Tube:
1. Identify each orifice or venturi tube with integral tab or stainless-steel tag.
2. Stamp on tag differential multiplier, orifice bore, rate of flow and equipment served.

3.02 INSTALLATION:

A. Cement nameplates with permanent adhesive on equipment and apparatus.

B. Affix labels to surface of control and switch boxes by means of sheet-metal rivets. Cement labels to surface with permanent adhesive when rivets cannot be used.

C. Fasten tags securely to valves, orifice flange, venturi tube with brass jack chain, so as to permit easy reading.

D. Mount valve charts in aluminum frames with clear Lucite front cover in locations as directed.

E. Fire-Protection and Suppression System:
1. Stencil legends on piping as shown to identify service and direction of flow.
2. Stencil vent-shaft and fan-shaft identification as shown on piping adjacent to angle hose valves in tunnels.
3. Stamp information on Authority-furnished identification plates as shown and fasten to sleeve on siamese fire-department connections for tunnel systems as shown.

END OF SECTION

SECTION 15080

INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing insulation.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. NFPA: 90A.
   3. ASTM: C240, C534, C552, C1071, E84.
   4. FS: HH-I-558.
   5. MS: MIL-A-3316, MIL-B-19564, MIL-C-19565, MIL-C-20079.
   6. SMACNA: HVAC Duct Construction Standards – Metal and Flexible

B. Each item listed in UL Building Materials Directory.

C. Fire-Hazard Ratings:
   1. Determine fire-hazard ratings in accordance with ASTM E84.
      a. Insulation, fastener, and jacketing materials, except flexible cellular plastic for expansion joints: Not exceeding 25 for flame spread, 50 for fuel contributed and 50 for smoke developed.
      b. Use of flameproofing and fireproofing treatments for the purpose of achieving specified fire-hazard ratings for insulation not meeting specified requirements is prohibited.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Label each item with manufacturer's name and brand designation, referenced specification number, type, class and thermal and acoustical rating as applicable.

B. Ship each type of insulation and accessory materials securely packaged and labeled for safe handling in shipment and to avoid damage.

C. Store materials in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. External Ductwork Insulation with Vapor-Barrier Facing:
   1. Insulation:
      a. Rigid board for exposed ductwork:
         1) Thickness: One inch.

2) Density: Three pounds per cubic foot.
3) Vapor-barrier facing: As specified, factory-applied.
4) FS HH-I-558, Form A, Class 2.

b. Flexible duct wrap for concealed ductwork:
1) Thickness: Two inches.
2) Density: 1.5 pounds per cubic foot.
3) Vapor-barrier facing: As specified, factory-applied.
4) FS HH-I-558, Form B, Type I, Class 6.

2. Vapor-barrier facing: foil-reinforced kraft paper.

B. Internal Ductwork Insulation:

1. Optional materials:

a. Flexible insulation:
1) Thickness: One inch.
2) Density: Three pounds per cubic foot.
3) Smooth coating on inside.
4) ASTM C1071 and NFPA 90A.

b. Fibrous-glass insulation:
1) Thickness: One inch.
2) Density: Three pounds per cubic foot.
3) Perforated, galvanized-sheet metal inner lining, lining as specified.

2. Minimum normal incidence sound absorption coefficients based on insulation thickness of one inch:

Cycles per second	125	250	500	1000	2000	4000
Coefficient	0.11	0.22	0.60	0.85	0.82	0.91

3. Maximum increase in friction loss of air due to duct insulation: 15 percent at 2,000 feet per minute velocity.

C. Piping Insulation:

1. General:

a. Vapor-permeance resistance:
1) Maximum vapor permeance: 0.5 percent by volume.
2) Vapor-permeance ratings for piping insulation determined in accordance with ASTM C240.

2. Chilled-water piping insulation:

a. Rigid premolded cellular glass: Covered with aluminum jacket 0.016-inch thick; ASTM C552.

b. Rigid premolded insulation sleeving: Thermal-pipe and tube covering, mineral fiber, industrial-type covered with aluminum jacket 0.016-inch thick; ASTM C552, all-service jacket.

c. Insulation for buried or embedded pipe: As specified or rigid polyurethane, one-inch thick, ASTM C552.

3. Insulation for pump discharge lines, force sewer mains and hot/cold potable-water piping:

a. Pipe, valves, flanges and fittings: As specified for chilled-water piping except insulation to consist of one layer, one-inch thick.

b. Insulation not required on embedded or buried pipe.

4. Refrigerant-piping insulation:

a. As specified for chilled-water piping except insulation to consist of one layer, one-inch thick.

D. Chilled-Water Pump Insulation:

1. Rigid premolded cellular glass: Two inches thick, ASTM C552.

E. Chiller Insulation:
   1. Insulation:
      a. Semi-rigid fibrous-glass board: 1-1/2 inches thick; FS HH-I-558, Form A, Class 1.
      b. Cellular glass, rigid blocks or boards: Two inches thick; ASTM C552.
   2. Vapor-barrier coating: Resistant to fire and water; MS MIL-C-19565, Type 1.
   3. Fire-resistant lagging adhesive: MS MIL-A-3316, Class 1.
   4. Metal bands for securing insulation in place: Type 316, stainless steel, minimum thickness 0.016 inches, minimum width 1/2 inch.
   5. Glass cloth: MS MIL-C-20079, Type I, Class 2.

F. Air-Separator Insulation:
   1. As specified for chilled-water pump.

G. Compression-Tank Insulation:
   1. As specified for chiller.

H. Expansion-Joint Insulation: Flexible unicellular, ASTM C534, one-inch thickness, two layers.

I. Wire Mesh: Galvanized wire, 22-gauge, one-inch mesh welded.

J. Corner Beads: Galvanized steel, 26-gauge, 2 1/2-inch wings.

K. Rigid-Insulation Adhesive and Sealer: Cold-applied, nonhardening asphaltic-type, in accordance with MS MIL-B-19564.

L. Vinyl-Emulsion Mastic: As recommended by manufacturer of rigid insulation.

M. Bore Coating: Anti-abrasive vinyl-base type as recommended by manufacturer of rigid insulation.

N. Sheet Metal Duct Lining: Galvanized sheet metal, 22 gauge, perforated with 3/32-inch holes on 3/16-inch centers, with 22-percent open area.

O. Fabric Pipe Jacket: Prefabricated laminate containing 10-by-10 asphalt-impregnated glass fabric and aluminum foil one-mil thick, sandwiched between three layers of bituminous mastic, for use on embedded or inaccessible piping.

P. Metal Pipe Jacket:
   1. Galvanized sheet steel, 24 gauge (U.S.S.) having Z-type longitudinal joint seam.
   2. Aluminum alloy, 0.016-inch thick, mill-finish, having Z-type longitudinal joint seam.

Q. Insulation-Hanger Shields: Aluminum alloy, minimum 0.050-inch thick, mill-finish, covering bottom 180 degrees of pipe insulation, lengths as follows:

Pipe Sizes/Inclusive	Shield Length
1/2 inch to 2 inches	6 inches
2-1/2 inches to 6 inches	9 inches
6 inches to 12 inches	12 inches

PART 3 - EXECUTION

3.01 APPLICATION OF INSULATION:

A. General:
1. Do not apply insulation until all surfaces to be covered are clean, dry and free of foreign materials, such as oil, grease, rust, scale and dirt.
2. Apply only clean and dry insulation.
3. Install insulation in accordance with manufacturer's recommendations as a minimum requirement.
4. Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces.
5. Provide continuous insulation through sleeves and openings except pipe sleeves piercing exterior walls, floors and ceilings below ground level.
6. Stagger joints with respect to adjacent butt joints.
7. Unless otherwise shown, insulate the following:
   a. Platform and mezzanine air-conditioning supply ductwork.
   b. Ancillary-area air-conditioning ductwork, supply and return, except ductwork within air-conditioned space.
   c. Ancillary-area heating ductwork, ventilating ductwork and combined heating and ventilating ductwork, supply and return except ductwork within heated space.
   d. Outside-air intake ductwork.
   e. Exhaust-air ductwork between automatic damper on discharge side of fan and louver, except underplatform and dome exhaust-air ductwork where insulation is not required.
8. The Contractor has the option of applying insulation internally or externally, except for the following required internal applications:
   a. Where shown.
   b. Insulated ductwork exposed to weather.
   c. Air-conditioning pylons.
   d. Air-conditioning ductwork under platform.

B. External Ductwork Insulation:
1. Install insulation continuously through openings provided for passage of ductwork and unbroken over seams, angles, hangers and other accessories.
2. Do not use scrap pieces of insulation to make up full-length sections. Eliminate voids by refitting or replacing insulation.
3. Rigid board for exposed ductwork:
   a. Fasten to duct with mechanical fasteners spaced 12 inches to 18 inches on center, with minimum of two rows on each side of duct.
   b. Secure with washers firmly embedded in insulation.
   c. Seal joints, breaks and punctures with fire-resistant vapor-barrier coating reinforced with a three-inch wide vapor-barrier strip.
4. Flexible duct wrap for concealed ductwork:
   a. Adhere to duct with fire-resistant adhesive in sufficient quantities to prevent sagging.
   b. Secure insulation tightly to the ducts with Type 316 stainless-steel insulation bands spaced 12 inches maximum center-to-center.
   c. For duct widths over 30 inches, secure on underside of duct with mechanical fasteners on 18-inch centers.
   d. Butt insulation, overlap joints with vapor-barrier facing two inches minimum; seal with fire-resistant vapor-barrier adhesive.
   e. Seal breaks and punctures with vapor-barrier strip and coating.

C. Internal Ductwork Insulation:
1. Install insulation in accordance with manufacturer's recommendations based on velocity and duct dimensions and SMACNA HVAC Duct Construction Standards -- Metal and Flexible.

2. Where insulation has perforated galvanized-sheet-metal inner lining, fill space between liner and outer duct, leaving no void spaces or unlined sections.
3. Do not use scrap pieces of insulation to make up full-length sections. Eliminate voids by retrofitting or replacing insulation.
4. Apply adhesives, where required, in accordance with manufacturer's recommendations.
5. Increase both width and height dimensions of duct by two inches from dimensions shown.

D. Chilled-Water Pump Insulation:
1. Rigid premolded cellular glass: Two inches thick, ASTM C552.

E. Piping Insulation:
1. Chilled-water piping:
   a. Insulation thickness:
      1) Rigid premolded cellular glass:
         a) Pipe sizes four inches and smaller: Install two layers of one-inch thick insulation on supply and return piping, valves and fittings.
         b) Pipe size five inches and larger: Install one layer of two-inch thick insulation on supply and return piping, valves and fittings.
      2) Rigid premolded insulation sleeving: Install one layer of two-inch thick on supply and return piping, valves and fittings as follows:
         a) IPS sizes: 1/2 inch through 30 inches.
         b) Copper tubing: 1/2 inch through 6-1/8 inches.
2. Pump discharge lines, force sewer mains and potable-water piping:
   a. Install insulation on pump discharge lines, force sewer mains, hot and cold potable-water piping, valves, flanges and fittings conforming to insulation installation specified for chilled-water piping except that insulation consists of one one-inch thick layer.
   b. Asphalt-paper inner jacket not required.
3. Refrigerant-piping insulation:
   a. Install insulation consisting of one layer, one-inch thick and finished as specified for chilled-water piping.
4. Embedded or inaccessible-piping insulation:
   a. Install insulation consisting of layers or thickness specified for usage specified.
   b. Provide inner jacket of prefabricated-fabric pipe jacket.
   c. Coat exposed surface of fabric pipe jacket with protective plastic film and inner surface with special-release paper.
   d. Apply jacket of galvanized steel over inner jacket.
   e. For flanges, valves and other fittings, apply aluminum jacket with paper backing or asphalt adhesive over galvanized-steel jacket. Secure by means of straps as specified.
   f. Over elbows provide mitered insulation covered with aluminum jacket material.

F. Application of Insulation on Pipe Saddles:
1. Cut two-inch thick piece of premolded pipe insulation of same material as used on piping, slightly larger than void formed by outer pipe circumference and pipe saddle.
2. Press insulation into void by hand pressure, so that both ends project slightly beyond each end of saddle.
3. Cut ends of insulation flush with saddle ends.
4. Use of filler, adhesive or other material to fill voids or imperfections in insulation is prohibited.

G. Expansion Joints for Piping Insulation:
   1. Install expansion joints in both horizontal insulation and vertical runs of piping on centers not to exceed 50 feet.
   2. Install joints one-half inch wide and fill with cushioning material in accordance with insulation manufacturer's recommendations.

H. Insulation for Anchors:
   1. Insulate anchors which are secured directly to cold piping as specified for a minimum distance of eight inches from surface of pipe insulation and sufficient to prevent sweating.

I. Application of Chilled-Water Pump Insulation:
   1. Install two-inch thick insulation as complete unit or in sections, constructed so that insulation can be removed and replaced without damage.
   2. Fit insulation snugly against pump without voids.
   3. Bevel curved surface edges to provide tight joint.
   4. Provide metal insulation covers with metal fasteners, supports, frames and membranes.

J. Application of Chiller Insulation:
   1. Insulate water-cooler shell, water boxes of water cooler, exposed suction piping and cold gas-inlet connection to hermetic-unit motors.
   2. Exposed suction piping: As specified for chiller-water piping
   3. Cooler shell:
      a. Cut and miter insulation to fit contour of surface. Secure in place with bands not over 12 inches on center. Stagger and seal joints with vapor-barrier mastic.
      b. Apply tack coat of adhesive conforming to MS MIL-A-3316, Class 1, at 60 to 70 square feet per gallon by spray or brush. Embed glass cloth into wet coating, smoothing to remove wrinkles. Overlap seams at least two inches. By spray or brush apply finish coat of lagging adhesive to entire fabric surface at rate of 60 to 70 square feet per gallon. Apply finish coat not later than one hour after tack coat.
   4. Removable heads and water boxes:
      a. Cover removable heads and water boxes with galvanized-steel box, 22-gauge minimum, constructed as complete unit or in sections. Construction to permit removal and replacement of covers without damage to insulation.
      b. Line metal covers with insulation of type and thickness used for cooler shell. Impale insulation on weld pins and secure with speed washers.
      c. Seal voids and joints with vapor-barrier mastic to prevent infiltration of moisture in space between insulation and metal cover.

K. Application of Air Separator Insulation:
   1. As specified for chilled-water pump.

L. Application of Compression-Tank Insulation:
   1. As specified for chiller.

END OF SECTION

SECTION 15135

MISCELLANEOUS PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing pumps, complete with motor drives and controls, except drainage pumping systems, chilled-water pumps and condenser-water pumps.

B. Related Work Specified Elsewhere:
1. Piping systems: Section 15205.
2. Raceways, boxes and cabinets: Section 16130.
3. Wire, cable and busways: Section 16120.
4. Motors: Section 16225.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. UL, NEMA 250.

B. Source Quality Control:
1. Select pumps based on capacity, total dynamic head and electrical characteristics shown.
2. Test pumps at 1-1/2 times working pressure.
3. Balance impeller statically, dynamically and hydraulically.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements specified for each:
1. Shop Drawings.
2. Certification.
3. Operation and Maintenance Manuals:
4. Submit for each pump.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIAL:

A. General Requirements:
1. In design and purchase of equipment, provide for interchangeability of subassemblies, parts, motors, starters and relays.

B. Hot-Water Circulating Pump:
1. Type: Centrifugal, single-stage, single-suction, in-line, hydraulically balanced and electric-motor-driven.
2. Minimum capacity: As shown.
3. Operating speed: 1,750 rpm.
4. Designed in accordance with the following:
   a. Standards of Hydraulic Institute.
   b. Pump supported by piping system.

c. To permit complete servicing without severing pipe connection.

5. Construction: Bronze, with stainless-steel or heat-treated steel shafts, with the following additional requirements:
   a. Bearings: One of the following:
      1) Ball bearings, frictionless with permanent grease lubrication.
      2) Sleeve bearings, oil-lubricated.
   b. Roller bearings, with oil reservoir.
6. Casing: Suitable for working pressure of 125 psig.
7. Seals: Mechanical, designed and guaranteed for long life in hot-water systems operating at 250F.
8. Motors: As specified in Section 16225.

C. Submersible Sump Pump:
1. Type: Automatic, electric-motor-driven, centrifugal, wet-pit, close-coupled.
2. To include single-phase, hermetically sealed, capacitor-start motor with built-in overload protection, upper and lower bearing factory-sealed, grease-lubricated ball-type, common shaft of stainless steel, Type 316, and sealed pump cable with neoprene cover and flexible armor. Motors to have cooling characteristics permitting continuous operation in totally submerged, partially submerged and non-submerged condition.
3. Casing: Close-grain cast iron, volute-type.
4. Impeller: Cast bronze, enclosed or semi-open, with vanes and back shroud, dynamically balanced.
5. Intake protected with slotted cast-iron or perforated steel intake strainer with effective free area sufficient to prevent cavitation and poor efficiency.

D. Liquid-Level Control:
1. Simplex submersible, single-phase unit, one of the following:
   a. Integral with pump, designed for direct switching of single-phase pumps, complete with ON/OFF, adjustable-level float switches.
   b. Completely independent, designed for direct switching of single-phase pumps and consisting of control box, contactor and ON/OFF level float switches.
      1) Control box of heavy-duty plastic having three-prong male plug for plugging into standard three-wire grounded power-supply outlet; grounded female socket into which cable from pump motor is plugged and heavy-duty contactor with 90-ampere lock-rotor rating for direct switching of motor load.
      2) Float switches for ON and OFF level switching connected to control box with extra-flexible, neoprene-jacketed electrical cable. Float switches UL-listed. Floats strapped to discharge pipe at required ON and OFF levels. Mercury switch with molybdenum contacts sealed in each double-walled float enclosure. Float enclosure of heavy-duty rigid plastic, resistant to attack by inorganic salt solutions, alkalis and mineral acids.
2. Duplex submersible, single-phase unit. Completely independent, designed for direct switching of two single-phase pumps and consisting of duplex control box, contactors, alternator, and ON/OFF and emergency-level float switches.
   a. Weatherproof, UL-listed, steel control box with gasketed removable cover containing contactor with 90-ampere lock-rotor rating for each pump, electric-alternator circuit and control-circuit fuse. Pump starting alternated at ON level on successive cycles. Second pump starts at EMERGENCY level if inflow exceeds capacity of first pump or is inoperative.
   b. Float switches for ON, OFF and EMERGENCY level switching, connected to control box with extra-flexible, neoprene-jacketed electrical cable. Float switches UL-listed. Floats strapped to discharge pipes at required ON, OFF

and EMERGENCY levels. Mercury switch with molybdenum contacts sealed in each double-walled enclosure. Float enclosure of heavy-duty rigid plastic, resistant to attack by inorganic salt solutions and mineral acids.

c. Alternator:
   1) Electric, automatic.
   2) Designed to alternate pumps on each successive cycle of operation and to operate both pumps automatically when one pump is unable to handle flow.
   3) Enclosure for electrical components: NEMA 250, Type 1.

E. Wiring:
   1. Control panel: Completely wired at the factory prior to shipment.
   2. Wiring and conduit: Sections 16130 and 16120.

F. Nameplates:
   1. Securely attached to each major item of equipment. In each case, show manufacturer's name, model number, serial number, electrical and operating characteristics.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances within space provided and make readily serviceable.

B. Provide hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer.

C. Install in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL:

A. Ensure that connections are secure and watertight.

B. Test system through five complete operating cycles.

C. Ensure that pump and motor operate without noticeable vibration.

END OF SECTION

SECTION 15205

PIPING SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing piping, fittings, valves, drains, specialties and supporting devices.

B. Related Work Specified Elsewhere:
1. Water distribution system: Section 02515.
2. Sanitary sewer: Section 02535.
3. Firestopping: Section 07841.
4. Field painting: Section 09920.
5. Stray current and cathodic protection: Section 13110
6. Corrosion control testing system: Section 13115.
7. Fire protection, suppression and alarm: Section 13905.
8. Identification of mechanical equipment and piping: Section 15075.
9. Insulation: Section 15080.
10. Grounding and bonding: Section 16060.

1.02 QUALITY ASSURANCE:

A. Qualifications of Welder: Section 05120.

B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. The Model Plumbing Code.
3. ASSE Standards.
4. AWWA Standards.
5. ASME Code for Unfired Pressure Vessels.
6. ANSI/ASME: A21.15/C115, B16.1, B16.3, B16.5, B16.9, B16.11, B16.18, B16.22, B16.39, B31.1, Z21.22.
7. ANSI/AWS: A5.8, E8016, E8018.
8. CISPI: HSN 85.
9. FS: A-A-1192, SS-C-153C, WW-P-51F, WW-P-460D, WW-P-501, WW-U-516B, WW-U-531, WW-V-51F.
10. MSS: SP-58, SP-67, SP-70, SP-80.
11. PDI: WH-201.
12. ASTM: A53, A74, A105, A126, A234, A276, A395, A536, B32, B61, B62, B88, B150, B280, B306, F709.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Complete catalog information and shop drawings for material and equipment.
   b. Submittals include, but are not limited to, the following:
      1) Pipes and piping layout, including locations of hangers and supports.
      2) Pipe hangers and supports.
      3) Valves.

4) Cleanout deck plates and wall plates.
5) Escutcheons.
6) Gauges.
7) Expansion joints, guides and anchors.
8) Air eliminators.
9) Pipe sleeves.
10) Drains.

2. Certification:
   a. Certificates from manufacturers verifying the following:
      1) That pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified.
      2) That expansion joints are designed and tested as specified.

1.04 JOB CONDITIONS:

A. Do not perform welding when the temperature of base metal is less than zero degree F.

B. Do not perform welding when surfaces are wet from rain, snow, ice or during periods of high wind unless operator and work are properly protected.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:
   1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies and parts.

B. Piping:
   1. Cast-iron soil pipe and fittings:
      a. Inside of or embedded within structures: ASTM A74, Class SV, uncoated.
      b. Passing through underground structural elements or buried below or outside structures: ASTM A74, Class XH, uncoated.
      c. Pipes, including embedded pipe crossing structural contraction joints, provided with modified bell and spigot joints with molded-neoprene elastic compression gaskets.
      d. Gaskets: CISPI HSN 85.
      e. Pipe and fittings manufactured with spigot ends plain and beveled.
      f. Bells modified to receive gaskets.
   2. Steel pipe and fittings:
      a. Seamless piping: ASTM A53, Types Grade B, hot-dip galvanized, Schedule 40, provided for the following applications:
         1) Waste and drainage piping and fitting, 2-1/2 inches and smaller where embedded or otherwise inaccessible.
         2) Dry vents where embedded or otherwise inaccessible.
         3) Chilled-water and condenser-water supply and return embedded or otherwise inaccessible.
      b. Fittings for chilled water, condenser water: ASTM A234 and ANSI/ASME B16.9 for dimensions and tolerances but not chemical properties.
      c. Flanges: ASTM A105 and ANSI/ASME B16.5 for dimensions and tolerances.
      d. Fittings and flanges furnished with properties equal to or greater than that of adjacent pipe.
   3. Ductile-iron pipe and fittings:
      a. Embedded or otherwise inaccessible piping: ANSI/ASME A21.15/C115, 250-pound pressure class.

b. Piping for sewage-ejector discharge, drainage-pump discharge, interim pumps and for water service from point of connection to inside of structure: ANSI/ASME A21.15/C115, 250-pound pressure class, flanged.
   1) Flanges: ANSI/ASME B16.1.
c. Pipe coated on outside with bituminous coating and lined with cement mortar of twice standard thickness specified for pipe size used.
   1) Cement-mortar lining having a seal coat of nontoxic, taste and odor-free bituminous material.
d. Neoprene gaskets furnished for joints.

4. Copper tubing and fittings:
   a. Copper tubing for potable water and for control air where embedded or otherwise inaccessible: ASTM B88, Type K, hard-drawn.
   b. Provide copper tubing for potable water, control air and pneumatic sewage-ejector compressed air where accessible: ASTM B88.
      1) Potable water and control air: Type M.
      2) Potable water and control air installed in conduit: Type K, annealed and lengths of piping 100 feet or less continuous without joints.
      3) Pneumatic sewage-ejector compressed air: Type K, hard-drawn.
   c. Fittings for potable-water piping: ANSI/ASME B16.22.
      1) Fitting wall thickness after forming not less than that of adjacent piping.
   d. Fittings for control-air piping: Wrought copper, solder joint except at apparatus connections where brass compression fittings furnished.
   e. Maximum pressure drop for high-pressure control-air mains: Five psi per 1,000 feet, with minimum 1-1/2 cubic feet per minute of 75-psi air flowing for each single station served and one cubic foot per minute for chilled-water plant.
      1) Minimum size for high-pressure control-air mains connecting chiller plants and underground stations: One-half inch ID, 5/8-inch OD.
   f. Control-air piping graded to low points and each low point provided with 3/8-inch drain cock.
   g. Solder joints: Lead-free 95.5-percent tin, 4.0-percent copper and 0.5-percent silver with non-corrosive flux; ASTM B32.
5. Copper drainage tube (DWV) and fittings:
   a. Seamless tubing: ASTM B306, No. 122 for drainage, waste, and vent piping and fittings.
6. Copper tubing for refrigerant service:
   a. Seamless copper tubing: ASTM B280 for refrigeration service.
   b. Fittings: Pure wrought copper, recessed solder joint, ANSI/ASME B16.18.
   c. Solder joints: Brazing filler metal in accordance with ANSI/AWS A5.8 and the following:
      1) Copper to Copper - 12-percent Sil-Foss (no flux 1300F).
      2) Copper to Copper - 6-percent Dyna-Flow (no flux 1350F).
      3) Copper to Steel - 45 silver solder (white flux 1150F)
7. Condensate-drain pipes:
   a. Hard-drawn copper: ASTM B88, Type L.
8. Unpolished stainless-steel drip pans:
   a. Provided under water, waste or condensate-drain piping which run over transformer vaults or electric motor starters.
   b. Each drip pan provided with one-inch drain.
9. Black-steel seamless pipe and fittings:
   a. Exposed chilled water, condenser-water supply and return piping: ASTM A53, Standard Weight Schedule 40.
   b. Pipes 1-1/2 inch and smaller connected with socket-weld fittings or screwed fittings.
   c. Pipes two inches and larger connected with welded fittings.

d. Pipes larger than 12 inches in diameter: Minimum 3/8-inch wall.
e. Threaded-pipe fittings: FS WW-P-501, Type I, Class B.
f. Welding fittings made of same schedule or weight classification as the pipe.
1) Factory-made welding fittings.
2) Mitered joint elbows and field-made reducers will not be permitted.
g. Butt-welded fittings larger than 1-1/2 inches: ANSI/ASME B16.9.
h. Socket-welding fittings: ANSI/ASME B16.11.
i. Flanges for welded piping system: ANSI/ASME B16.5, forged steel, welded-neck type, 150-pressure class.
j. Black-steel pipe and fittings for drainage in aboveground structures as specified in a., except Weight B piping furnished.

10. Unions:
a. 1-1/2 inch and smaller: Threaded, ASME B16.39, Type A or B to match piping.
b. Two inch and larger unions: ASTM A126, Class B, flanged.
1) Two, 2-1/2 and three-inch union flanges: Steel, FS WW-U-531 or of cast iron, ANSI/ASME B16.1, 125-pound class.
c. Four inch and larger union: Forged steel, 150-pound class, slip-on weld-neck flanges, ANSI/ASME B16.5.
d. Nonferrous-piping unions: Brass, FS WW-U-516B.

11. Cleanouts:
a. For cast-iron bell-and-spigot pipe: SVCI, ferrule caulked into cast-iron fittings and extra-heavy brass tapered screw plug with recessed head.
b. For wrought-iron pipe: Extra-heavy brass plug in drainage fitting.
c. Floor cleanouts: Cleanouts turning up through architecturally finished floors made by means of a long-sweep ell or Y and adjustable ABS housing with secured, scoriated, round satin-brass cover.
d. Wall cleanouts: Cleanout plugs furnished with solid head tapped for 1/4-inch brass machine screw to secure coverplate. Coverplate to be polished-brass round access plate secured to plug with countersunk screw.
e. For threaded pipes: Bronze, FS WW-P-460D, Class A.
f. Furnished with adjustable recessed head in floor and where shown.
g. Except for test openings, cleanout plugs for pipes up to four inches to be same size as pipe.
h. On pipe sizes five inches and larger, cleanout plugs to be of four inches and pipe reduced to plug size with bushing.

C. Valves:
1. Gate valves two inches or smaller:
a. MSS SP-80, Type 2, Class 150.
b. Bronze with threaded ends, rough bodies and finished trim.
c. Materials except handwheels: ASTM B61.
d. Furnished with malleable-iron hand wheels.

2. Gate valves 2-1/2 inches and three inches:
a. MSS SP-70, Type 3, Class 125, OS&Y flanged end, Type I, Class 2, cast-iron bodies and bonnets.
b. Seat rings, disc, disc guide and stem furnished in bronze.
c. Outside stem and yoke (OS&Y), flanged-end connections and malleable-iron hand wheels.

3. Gate valves four inches and larger:
a. MSS SP-70, Type 2, Class 125, OS&Y, flanged end, cast-iron bodies and bonnets.
b. Seat rings, disc, disc guide and stem furnished in bronze.
c. Outside stem-and-yoke type and cast-iron hand wheels.

4. Globe, angle and check valves:
a. Two inches and smaller:

1) WW-V-51F, Class B.
2) Bronze with threaded ends, rough bodies and finished trim.
3) Materials except hand wheels: ASTM B61.
4) Globe and angle valves furnished with malleable-iron hand wheels.
5) Check valves four inches and larger:
a) Swing-type valve seat, with iron or steel body and cap and flanged-end connections.
b) 150-pound class, renewable arm, disc assembly and seat ring with bronze trim.
c) Outside arm and weight for pump discharge check valves.

5. Valves for copper piping:
a. Gate valves with solder ends: MSS SP-80, Type 2, Class 150, Bronze, Type 1, Class B.
b. Gate valves with flanged ends: MSS SP-80, Type 2, Class 150, Bronze.
c. Globe, angle and check valves with solder or flanged ends: FS WW-V-51F, Bronze, Class B.

6. Pressure-reducing valves:
a. Direct-acting type in which diaphragm and spring act directly on valve stem.
b. Constructed to ensure that delivered pressure does not vary more than one psi for each ten-psi variation in inlet pressure.
c. Wearing parts readily renewable.
d. Valves two inches and smaller designed for working pressure of 250 psi, brass construction except yoke connecting valve body to separate diaphragm chamber having brass cover and assembled with brass bolts.
e. Valves larger than two inches designed for minimum 125 psi, iron bodies and bronze trim.
f. Adjustable to any outlet pressure.
g. Gate valve and union on both inlet and outlet connections.
h. Provided with bypass one pipe-size smaller than main water line.
i. Stem-mounted pressure-reducing valve gauges, 3-1/2 inch dial, solid brass or stainless steel case and connections with T-handle stops.
j. Pressure-reducing valve strainer: Brass, removable without disconnecting piping.
1) Strainers two inches and smaller: Brass, bodies designed for minimum working pressure of 250 psi.
2) Strainers 2-1/2 inch and larger: Iron bodies designed for minimum working pressure of 125 psi

7. Pressure-temperature relief valves:
a. Temperature-and-pressure-actuated type, adjustable, bronze, single disc with bottom guide to ensure proper seating.
b. Body, disc and base: Bronze, ASTM B62.
c. Spring and stem: Steel.
d. Lever: Malleable iron.
e. Pressure range from three psi to 250 psi rated and tested under ANSI/ASME Z21.22.
f. Temperature range: To 400F.

8. Automatic flow-control valve:
a. Individually selected by manufacturer to automatically limit rate of flow to design capacity, regardless of system fluctuations.
b. Selected to regulate flow within five percent of nameplate rating of system in which installed. Maximum operating differential between body tappings necessary for control not to exceed two psi.
c. Self-cleaning, cartridge-piston type with stainless-steel variable-area orifices.
d. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.

e. Tamperproof with body tappings for connecting instruments for verifying flow-control performance.
f. Threaded or flanged connections as required for pipe fittings.
g. Furnished with valve kit consisting of 1/8-inch by two-inch minimum size nipples, shutoff valves located outside of insulation and hose fittings for use with measuring instruments.

9. Refrigerant valves: UL listed.
10. Balancing cocks:
    a. Resilient-faced, eccentric-plug type designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
    b. Six inches and under, wrench-operated; eight inches and over, operated by worm or spur gear.
11. Line Strainers:
    a. Water strainers, Y or basket-type, 1-1/2 inches and smaller: ASTM A126, Grade B, iron bodies with screwed connections.
    b. Two inches and larger: ASTM A126, Grade B, iron bodies with flanged-end connections.
    c. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
    d. Stainless-steel or Monel screens as follows:
        1) Perforations:

Strainer size	Perforation size
3/4-inch to two-inch inclusive	1/32 inch
2-1/2 inch to six-inch inclusive	1/16 inch
Eight-inch to 12-inch inclusive	1/8 inch
Over 12 inches	5/32 inch

        2) Free area of screen minimum three times area of strainer inlet pipe.
    e. Strainer provided with 3/4-inch drain valve.
12. Backflow preventer:
    a. Reduced-pressure type with two check valves and automatically operated pressure-differential relief valve located between two check valves.
    b. Relief valve and discharge port to drain intermediate chamber to level below supply-line inlet.
    c. Moving parts and trim constructed of corrosion-resistant material.
    d. Equipped with test cocks.
    e. Conform to applicable section of ASSE and AWWA Standards.
13. Butterfly valves:
    a. MSS SP-67, sizes as shown.
    b. Provide extended necks or neck extenders to accommodate two inches of insulation.
    c. Provide 10-position latch-lock handles.

d. Provide enclosed work screw operators, sizes eight inches and larger.
e. Provide chainwheels when above normal reaching area.
f. Provide adjustable balance-return stops for balancing service.
g. Meeting MSS SP-67.
h. Test shell at 225 psi.
i. Body:
    1) Wafer-type, cast iron, ASTM A126, Class B, or lug-type, ductile iron, ASTM A536 grade 60-40-18, or ASTM A395.
    2) To fit between ANSI/ASME B16.5 flanges.
    3) Bodies with integral flanges or full lugs drilled.
j. Seat:
    1) Provide ethylene-propylene-terpolymer (EPT) bonded to rigid ring providing noncollapsible and replaceable seat.
    2) Provide bubble-tight shutoff of 150 psi at temperatures between 25F and 225F.
    3) Provide O-ring as secondary seal between seat and stem.
k. Disc:
    1) Aluminum-bronze: ASTM B150.
l. Stem:
m. Stainless steel: AISI Type 304, 316, 410 or 416.
    1) Isolate from contact with piped material.

D. Portable Flow Meters:
1. Factory-fabricated case, carrying handle and fitted to hold meter securely to accommodate the following accessories:
    a. Two 10-foot lengths of connecting hose with female connectors for venturi-tube pressure-tap nipples.
        1) Hose designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
        2) Completely assembled three-valve manifold with two block valves and vent and drain valves piped and mounted on base.
    b. Set of curves showing flow versus pressure differential for each orifice or venturi tube.
    c. Metal instruction plate, secured inside cover, illustrating use of meter.

E. Orifices and Venturis:
1. Stainless steel, square-edge type, mounted between pipe flanges with factory-made pressure taps.
2. Taps with shut-off valves and with quick-connection hose fittings for portable meters.
3. Orifice-throat diameter at specified flow and differential pressure in inches water gauge as follows:
    a. Fall in 60 to 80 percent of full scale reading for square-root meters.
    b. Twelve to 40 inches for linear-scale meters.
4. Venturi size selected with design flow rate between 10 and 40 inches of water-pressure differential.
    a. Permanent pressure loss: 25-percent maximum of indicated flow-rate differential pressure.
5. Flow-metering equipment: Supplied by same manufacturer.

F. Thermometers:
1. Dial-type, chromium-plated case, remote or direct-type bulb with accuracy of plus-or-minus one degree.
    a. Three-inch minimum dial with white face and black digits, graduated in two-degree increments.
2. Liquid-in-glass thermometers.

3. Thermometer ranges suitable for service at not less than 20 degrees above controlled temperature settings.

G. Thermometer Wells:
1. Stainless steel with portions surrounding bulbs not over 1/16-inch thick, designed to hold engraved-stem thermometer.
2. Six inches projecting two inches into pipe with dust-excluding caps with gaskets and chains.
3. Pipe smaller than 2-1/2 inches enlarged where wells are located.
4. Set vertical or at angle to retain oil.

H. Gauges:
1. ASTM F709, Class 1, 2 or 3, Style A, Type I or III with metal case.

I. Shock Absorbers:
1. Constructed of stainless steel, precharged with nitrogen, argon or pneumatic pure glycerine and permanently sealed.
2. Provided on cold-water supply piping to flush-valve water closets and urinals.
3. Provided on hot and cold supply piping to lavatories and mop service basins.
4. Certified to meet requirements of PDI WH-201.

J. Expansion Joints:
1. General:
   a. Designed for 150 psi and 200F for systems operating at 100 psi or less.
   b. Provide expansion joint traverse with 150 percent of pipe expansion resulting from temperature variation of 80F.
   c. Provide corrugated-bellows expansion joints for pipe expansion of 1-1/2 inches or less, minimum of 200 percent of expansion.
   d. 1-1/2 inches and smaller, threaded ends; two inches and larger, flanged ends.
2. Flexible ball joints:
   a. Carbon steel, providing 360 degrees rotation plus 15 degrees minimum angular-flexing movement, furnished with asbestos-composition gaskets, steam-molded in steam-heat presses.
3. Corrugated-bellows expansion joints:
   a. Bellows constructed of single-ply or multiple-ply, formed, corrugated stainless steel for pipe sizes smaller than three inches.
   b. Self-equalizing type with equalizing or reinforcing rings, internal-telescoping stainless-steel or Monel sleeves, removable steel housing to protect bellows and support insulation.
   c. Corrugated element: Seamless tubing or of single sheet of metal rolled into cylinder having one longitudinal seam for sizes up to 16 inches.
   d. Joints 2-1/2 inches and smaller: Internal guides and limit stops.
   e. Designed for a minimum life of 5,000 full-rated traverse cycles when tested at specified pressures and temperatures.

K. Supporting Devices:
1. Pipe hangers and supports:
   a. Provide adjustable steel pipe hangers and supports as follows:
      1) Clevis and clamp, cadmium-plated or zinc-plated: MSS SP-58, Type 1 and Type 8 for steel and cast-iron piping.
      2) With cast-iron roller and sockets: MSS SP-58, Type 41 for chilled-water piping.
      3) Space not greater than six feet for pipe sizes up to and including 1-1/2 inches; 10 feet for pipe sizes two inches through six inches; 16 feet for pipe sizes eight inches and larger

b. Pipe hangers for copper tubing: Steel, copper-plated, clevis-type, spaced at maximum five feet for tubing sizes through 1-1/2 inches and maximum eight feet for sizes two inches and larger.
c. Hanger rods minimum diameter 3/8 inch, constructed of steel, cadmium-plated, threaded full-length and diameter required by pipe size and load imposed.
d. Hanger rod nuts and washers: Steel, cadmium-plated.
e. Supported from malleable-iron, hot-dip galvanized inserts in concrete slab: MSS SP-58, Type 18.
f. Pipe hangers and supports in tunnels and shafts: MSS-SP-58, stainless steel, ASTM A276, Type 304.

2. Pipe rolls, plates and stands:
   a. Cast iron: MSS SP-58, Types 44, 45, and 46.
      1) Adjustable types selected for piping require grading after setting in place.
   b. Protection saddles for support piping: MSS SP-58, Type 39, welded to pipe.
3. Pipe anchors:
   a. Designed to withstand five times anchor load minimum.
   b. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.
4. Pipe guides:
   a. Factory-made cast semi-steel or heavy fabricated galvanized steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted or welded tight to pipe.
   b. Designed to clear pipe insulation and to prevent overtravel of spider and cylinder.
   c. Guides not less than 12 inches long and spiders not less than the following:

Pipe size/ inches	Spider length/ inches
1-1/2 and smaller	2
2 to 3	2-1/2
4	3
5 and larger	3-1/2

5. Expansion bolt anchors:
   a. Consisting of bolt, expander, star lock washer and nut.
   b. Fabricated of stainless steel, Type 303, including expander and star lock washer.
   c. Anchor assemblies: FS: A-A-1992, Group II, Type 4, Class 1.
6. Self-drilling anchors:

a. Self-drilling expansion anchors, with self-cutting annular broaching grooves.
b. Anchor and expander plug: FS: A-A-1992, Group III, Type 1, double-plated.

7. Pipe sleeves:
   a. Through interior masonry-unit walls: As shown. Sleeve to be large enough to accommodate pipe and covering but not less than two sizes larger than pipe size.
   b. Through poured-concrete interior walls, floors and ceiling: As shown.
      1) Sleeves minimum two sizes larger than pipe. At floors, sleeves to project four inches above finish floor.
   c. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.
   d. Sleeves designed to allow expansion/contraction movement of pipe.
8. Escutcheon plates:
   a. Polished brass or stainless steel, screw-fastened to wall or ceiling.
   b. Plate collars caulked watertight with mastic.
   c. Mastic: FS SS-C-153C, Type I.

L. Drains:
1. Area drains:
   a. Cast iron with flashing flange and flat grate for entrance areas.
   b. Outlets designed for connection to cast-iron soil pipe.
   c. Drain sizes and types as shown.
   d. Clamping devices: For securing membrane or flashing for drains installed in membrane-waterproofed floors and in floors not laid on ground.
2. Floor drains:
   a. Cast iron with flashing flanges and bottom or side outlet as required and designed for connection to cast-iron soil pipe.
   b. Clamping devices: For securing membranes or flashing, for drains installed in membrane-waterproofed floors and in floors not laid on ground.
   c. Reinforced-neoprene flashing: For drains installed in floors that are not membrane-waterproofed and are not laid on ground.
   d. Flashing of reinforced sheet neoprene, secured to drain by clamping device and extending 12 inches minimum from drain to ensure watertight connection.
   e. Area, yard and floor drains in public spaces having finished brass grates.
   f. Floor-drain sizes and types as shown.
3. Roof drains:
   a. Cast iron having integral flange and a clamping device for securing the roof covering to make a watertight connection.
   b. Drains for promenade roofs with removable, loose-set, round flat grate in square frame secured to nonpuncturing flashing clamp collar with weep holes and for two inch or more roof fill.
   c. Other roof drains furnished with cast-iron beehive or dome-shaped strainer.
   d. Openings in each strainer having a combined-area minimum twice the area of drain outlet.
   e. Each drain outlet having same size as downspout and with parts to make watertight connection to threaded pipe or cast-iron pipe as required.
   f. Meeting requirements shown.
4. Canopy drains (Roof Drain - Type 5):
   a. Ductile iron: ASTM A536, Grade 65-45-12.
   b. 30 square inches minimum grate free area.
   c. Removable gratings, contoured to match opening in concrete rib and as shown.

M. Air Separators:
1. Provide in-the-pipeline air separators with tangential openings for water in and out.

2. Design to create low-velocity vortex for internal separation of free air from water stream.
3. Size according to size of connecting pipeline as shown.
4. Equip with two-inch blowdown connection located at bottom of separator.
5. Equip with 1-1/4 inch minimum compression tank connection located at top of tank.
6. Tank:
   a. Size as shown and rated at 125-psi working pressure.
   b. Construct of carbon steel and in accordance with ASME Code for Unfired Pressure Vessels and so certified and stamped.
7. Strainer:
   a. Stainless steel with perforations sized for water flow.
   b. Install in location to assist in separation of air.
   c. Removable from bottom of separator.
8. Insulation: Section 15080.

N. Coal-Tar Epoxy Coating: Section 02535.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Welding Procedure:
1. Perform welding by manual metallic arc-process except for pipe sizes four inches and smaller where gas welding (oxyacetylene) may be used.
   a. Use electrodes and rods of composition recommended for pipe by AWS.
   b. Heat surface within three inches from point where weld will start to temperature warm to the hand before welding.
2. Weld corrosion-resistant nickel-copper alloy steel pipe by arc-process utilizing low-hydrogen electrodes of AWS E8016 or E8018 types.
3. Leave joint surfaces smooth, uniform, free from fins, tears and other defects which adversely affect proper welding.
4. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.
5. Peen with light blows of blunt-nosed peening hammer.
   a. Do not peen surface layers or first pass in groove welds.
6. For groove welds, have surface pass substantially centered on the seam, smooth and free from depressions.
7. Perform fillet-welds with minimum cutting back of outside pipe.
   a. Leave throat of full fillet-weld not less than 0.707 of thickness of pipe.
   b. Repair excess cutting back and undercutting of base metal in pipe adjoining weld.
   c. Fill up craters to full cross section of weld.
8. Align and position accurately joints to be welded, so that pipe will not project beyond its adjoining pipe by more than 20 percent of pipe wall thickness or 1/8-inch maximum.
9. Install welded pipe in accordance with ANSI/ASME B31.1.

B. Soil, Waste, Vent and Drainage-Piping Installation:
1. Grade piping to 1/4 inch per foot and not less than that of main drain to which it is connected.
2. Use reducers to change pipe sizes on vent and drain lines.
3. Use long-sweep bends, Y-fittings, 1/8 or 1/16-bends, or combination Y and 1/8-bends to make changes in direction.
4. Join service-weight soil pipe and fittings with service-weight gaskets and extra-heavy soil pipe and fittings with extra-heavy gaskets.
   a. Designate and clearly identify service-weight and extra-heavy gaskets.

b. Use lubricant for making joints.
c. Make tight seal between external face of pipe and internal face of bell.
d. Use gaskets capable of making and maintaining tight seal with deflection not exceeding five degrees.
e. Assemble joints by use of tools recommended by pipe, fittings and gasket manufacturers.
f. Employ trained workmen experienced in installation of gasket system to install entire gasket system.

5. Install embedded cast-iron piping at angle of 90 degrees to contraction joints with end of pipe bell coinciding precisely with centerline of contraction joint.
6. Cut ends of screw-jointed pipes squarely to seat in bottom of recess of fittings and ream after cutting so waterway is not reduced in size.
7. Apply thread dope or compound to male thread only.

C. Buried Ductile-Iron Pipe:
1. Install pipe with mechanical joints and neoprene gaskets and stabilize by use of thrust blocks.
2. Thrust blocks: Section 02515.

D. Potable-Water System Installation:
1. Connect and install service water piping, sizes as shown, to fixtures, equipment and outlets.
2. Install water meter in accordance with requirements of local water authority and provide the following valves:
a. Main shut-off gate valve inside service room ahead of water meter.
b. Drain with globe valve and hose nipple for 3/4-inch hose installed on house side of meter.
3. Pipe or tubing free from cuts, dents and other surface damage. Remove damaged pipe and replace with new pipe or tubing.
4. Cut square and ream ends of copper tubing.
5. Tubing ends to extend full depth of fitting recesses without binding.
6. Use lead-free 95.5-percent tin, four-percent copper and 0.5-percent silver solder with non-corrosive flux; ASTM B32.
7. Ream and clean ends of threaded pipes before assembling with fittings and apply approved joint compound to pipe thread only.
8. Make connections to equipment and fixtures without undue strain.
9. Run horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
a. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
10. Connect nonferrous piping to ferrous piping with dielectric couplings.
11. Install pressure-reducing valves where main water pressure exceeds 60 psi to maintain pressure of 15 psi at most remote fixture.

E. Control-Air Piping Installation:
1. Do not run piping concealed under duct insulation, inside of ducts or in direct contact with surfaces colder than normal room temperature.

F. Steel-Pipe Installation:
1. Weld embedded pipe and install so that pipe will not penetrate construction joints or structural contraction joints.
2. Install horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
a. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
3. Install high-capacity automatic air vents at high points, designed for 125 psi and suitable for operation on pressures under 125 psi.
a. Pipe air-vent outlet to floor drains.
4. Pipe drip pan to discharge as shown; if not shown, discharge to nearest open drain.

5. Provide flexible connections to coils, pumps and other equipment so as to eliminate undue strains in piping and equipment.
6. Install condensate-drain lines for each air-handling unit with pitch of 1/4 inch per foot in the direction of flow.
    a. Run drain lines to nearest open drain.
    b. Do not exceed 400 feet maximum length of pipe between anchor and expansion joint or 90-degree offset.
7. Do not support embedded pipe from reinforcing bars with metallic means.

G. Expansion-Joint Installation:
1. Field set expansion joints for position corresponding to ambient temperature at time of installation.
2. Setting based on manufacturer's calibration data furnished with expansion joints.
3. Do not use corrugated-bellows expansion joints where exposed in train tunnels.
4. Install ball joints in accordance with approved published recommendations of manufacturer.
5. Do not use shims or steel spacers.

H. Pipe Anchors:
1. Securely anchor piping where shown and where necessary for proper installation to force pipe expansion in proper direction.

I. Expansion-Bolt Anchors:
1. Drill holes and install expansion-bolt anchors as recommended by anchor-bolt manufacturer. Do not locate less than eight inches from concrete edge.

J. Pipe Sleeves:
1. Exterior walls:
    a. Install as shown.
    b. For cathodically protected pipe, test in accordance with Section 13115.
2. Interior walls:
    a. Install as shown. Seal to maintain integrity of walls.

K. Plumbing-Fixture and Equipment Connections:
1. Make connections to wall-hung water closets and urinals with adjustable flanged nipples secured to chair supports, wax rings and rubber or impregnated-felt gaskets.
2. Face plate of carrier not more than six inches from back of finish wall.

L. Drains:
1. Install floor drains with traps.

M. Air-Separator Installation:
1. Install air separator on suction side of chilled-water pump and as near to pump as practicable.
2. Install dead-level in both directions and support from structure so that pipe can be removed without moving air separator.
3. Install two-inch drain line, equipped with gate valve and union, from blowdown connection to nearest drain.

N. Attachments to Prestressed-Concrete Girders:
1. Attach pipes and similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except as shown.

O. Refrigeration Copper Tubing Installation:
1. Before heating joints, force nitrogen or carbon dioxide into the system.

2. Sweat each copper tubing installation joint in accordance with standard accepted practice.

P. Bonding: In accordance with Section 16060, and with the following additional requirements:
1. Bond mechanical joints and fittings , including valves, by exothermic-welding method.
2. Make welds in accordance with recommendations of the manufacturer. Clean and coat with coal tar epoxy.
3. Bond pipe using bonding strap welded to each side of joint not less than six inches from joint. Allow sufficient slack in conductor for expansion of pipe.

Q. Firestopping: Section 07841.
1. Pipe penetration through fire rated partitions to be sealed with approved fireproof sealant.

3.02 PROTECTION OF PIPING AND EQUIPMENT:

A. Protect pipe, openings, valves and fixtures from dirt, foreign objects and damage during construction.

B. Replace damaged piping, valves, fixtures and appurtenances.

C. Prior to testing, flush piping with chemically treated water until systems are clean and free of scale, slag, dirt, oil, grease and other foreign material.

D. Hand-clean expansion joints and strainers.

E. Coal-Tar Epoxy Coating for Protection of Ferrous Piping: Apply as specified in Section 02535 and test as specified in Section 13115.

3.03 FIELD QUALITY CONTROL:

A. Water-Pressure Testing:
1. Prior to burial or concealment, test affected piping in presence of the Engineer using specified procedures.
2. Test entire piping systems and test until found leak-free in presence of and to satisfaction of the Engineer.
3. Notify the Authority at least 36 hours in advance of making tests.
4. Test piping at following pressures:
   a. Soil, waste and vent piping: Requirements of local plumbing code but not less than equivalent to ten feet of water.
   b. Chilled-water and condenser-water piping embedded or otherwise inaccessible: 400-psi minimum.
   c. Ductile-iron pipe: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.
   d. Potable-water piping: 1-1/2 times operating pressure but not less than 100 psi at topmost outlet.
   e. Chilled-water and condenser-water piping, exposed and accessible: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.

B. Test Procedures:
1. Soil, waste and vent piping:
   a. Water test to include entire system from lowest point to highest point.
   b. After filling system, shut off water supply and allow it to stand two hours without loss or leakage.

c. Conduct final test by smoke test or peppermint test as prescribed by jurisdictional authority.

2. Chilled-water and condenser-water piping embedded or otherwise inaccessible:
   a. Avoid excessive pressure on safety devices and mechanical seals.
   b. Fill entire system with water and vent air from system at least 24 hours before test pressure is applied.
   c. Apply test pressure when water and average ambient temperatures are approximately equal and constant.
   d. Maintain test pressure for minimum of six hours without drop after force pump has been disconnected.
   e. Visually inspect joints while pipe is under test pressure.
3. Ductile-iron pipe and black-steel piping:
   a. Use procedure specified for chilled-water and condenser-water piping embedded or otherwise inaccessible.
4. Potable-water piping:
   a. Use procedure specified for chilled-water and condenser-water piping embedded or otherwise inaccessible, except tests may be conducted in sections as long as no pipes or joints are left untested.Air Testing:

C. Control-air piping:
1. Test main air piping at minimum of 150 psi and maintain pressure for one hour without pumping.
   a. Test low-pressure air piping at minimum of 30 psi and maintain pressure for one hour without pumping.
   b. Correct leaks by remaking joints.

D. Pressure Testing:
1. Refrigerant piping: Test at 300 psi on high side and 150 psi on low side.
   a. Maintain pressure for minimum of 12 hours.
   b. Use electronic leak detector to check leaks, after soap-bubble test.

E. Repair of Leaks:
1. Do not repair by mechanical caulking leaks in threads or welds occurring while pipeline is under test or in service.
2. Introduction into piping system of material intended to stop leakage is prohibited.
3. Repair leaks in threaded piping by breaking joint, cutting new threads on pipe and installing new pipe fitting.
4. Remove defective welds by chipping or gas gouging from one or both sides of joint.
   a. Reweld chipped-out places.
   b. When base metals of fillet-weld are cut back or throat of weld is less than specified, repair defect by adding additional weld metal.

3.04 DISINFECTION:

A. Adjust and Clean:
1. Flush entire hot and cold-water piping and other piping and equipment connected downstream from the domestic-water inlet main shutoff valve with water to remove sediment after completion of tests, replacements or repairs.
   a. Use chlorine for disinfection in form of hypochlorite solution or in form of compressed gas applied through approved chlorinator.
   b. Operate valves and equipment during chlorination to ensure that chlorine reaches entire system.
   c. Feed water and chlorination agent into system at rate providing for 50 ppm of chlorine and allow to stand 24 hours before flushing.
   d. Residual chlorine at end of 24-hour retention period: Two-ppm minimum.
2. Flush treated water from system completely after disinfection.

3. Continue flushing until samples show that quality of water delivered is comparable with public water supply and satisfactory to jurisdictional public-health authority.
4. Do not take samples from hydrants or through unsterilized hose.

3.05 FIELD PAINTING:

A. Paint exposed soil and waste pipe lines in accordance with Section 09920.

END OF SECTION

SECTION 15737

AIR CONDITIONING UNITS - AIR-COOLED SPLIT SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing air-cooled split-system air-conditioning units.

B. Related Work Specified Elsewhere:
1. Concrete pads: Sections 03100, 03200 and 03300.
2. Insulation: Section 15080.
3. Piping systems: Section 15205.
4. Filters: Section 15865.
5. Wire, cable and busways: Section 16120.
6. Conduit, raceways and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ARI: 210.
3. UL listed.

B. Design Criteria:
1. Select units in accordance with requirements shown.
2. Provide completely matched combination between evaporator unit and condensing unit.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
2. Certification.
3. Operation and Maintenance Manuals.

1.04 JOB CONDITIONS:

A. Safety Requirements:
1. Properly guard belts, pulleys, chains, gears and other rotating parts to prevent danger to personnel.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:
1. In design and purchase of equipment, provide for the interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
2. UL listed.
3. Meet ARI 210.

B. Evaporator Unit:
1. Cabinet:

a. Welded, constructed of heavy-gauge steel, zinc-coated or chemically pretreated, painted with enamel primer and exterior surface finished with factory-applied enamel coating.
b. Interior of cabinet completely lined with sound-absorbing thermal insulation resistant to moisture, vermin and rot.
c. Casing provided with insulated condensate-drain pan.

2. Evaporator coil:
a. Direct expansion, fabricated of seamless copper tubing with aluminum fins tightly bonded to tubing.
b. Selection of cooling capacity of coils based on space conditions and the following as shown:
1) Entering wet-bulb temperature at evaporator coil.
2) Entering ambient temperatures at condenser coil.
c. Factory-mounted thermal-expansion valve:
1) For units of 10 tons or more: Coils double-circuited and provided with two expansion valves.
d. Tested at minimum 300 psig.

3. Evaporator fan and motor:
a. Centrifugal fans of corrosion-resistant construction.
b. Fan wheels dynamically and statically balanced.
c. Fan belt drives designed for 150 percent of required fan-motor brake horsepower.
d. Motor mounted on adjustable base.
e. Brake horsepower selected to drive fan at air volume and static pressure shown.
f. Fan motors: Air-conditioning unit manufacturer's standard for intended use and location.

4. Filters:
a. Replaceable (throwaway)-type: Section 15865.

C. Air-Cooled Condensing Unit:
1. Casing:
a. Weatherproof suitable for outdoor installation.
b. Fabricated of heavy-gauge steel, zinc-coated or chemically pretreated, painted with enamel primer and exterior surface finished with factory-applied enamel coating.
c. Removable panels provided for access to accessories

2. Condenser coils:
a. Air-cooled, fabricated of seamless copper tubing with aluminum fins tightly bonded to tubing.
b. Condenser coil capable of total heat rejection based on condensing and ambient temperature shown.
c. Tested at minimum 425 psig.

3. Condenser fan and motor:
a. Fan of corrosion-resistant construction.
b. Fans dynamically and statically balanced.
c. Fans protected with heavy-gauge welded-wire fan guards.
d. Motors: Air-conditioning unit manufacturer's standard for intended use and location.

4. Compressor:
a. Hermetically semi-hermetic sealed, refrigerant-cooled, suitable for operation with refrigerant R-22.
b. Capacity control provided for compressor of 10 tons and more to permit partial operation at low-load conditions.
c. High and low-pressure cutouts.
d. Compressor motor protected by means of overload relays and internal-winding thermostat.

e. Compressor mounted on internal spring isolator or on rubber-in-shear mounting pads.
f. Number of compressors:
1) For units rated up to and including 7-1/2 tons: One compressor.
2) For units rated at 10 or more tons: Two compressors with two separate refrigerant circuits.

5. Refrigerant piping: Section 15205.
6. Refrigerant-piping insulation: Section 15080.
7. Refrigeration circuits:
a. Provide the following components in refrigeration circuits:
1) Back-seating service valves in liquid and hot-gas lines.
2) Filter drier on liquid line.
3) Moisture-indicating sight glass on liquid line.
4) Charging valves on suction side.
5) Hot-gas muffler on discharge side.

D. Air-Cooled Split-System Air-Conditioning Unit Controls:
1. Factory-wired in separate control cabinet mounted on exterior of condenser casing.
2. Heating and compressor contactors.
3. Condenser and evaporator-fan contactors.
4. High-pressure cutout with automatic reset.
5. Low-pressure cutout with manual reset.
6. Reset relay to prevent unit from cycling on automatic resetting of safety controls.
7. Noncycling pumpdown control.
8. Controls provided near evaporator unit:
a. Room-air thermostat heating/cooling control for systems incorporating electric-duct heaters.
b. Damper operators.
9. Pushbutton selector switch for OFF/FAN/COOLING/HEATING operations, mounted on evaporator unit.
10. Control sequence:
a. Room-air thermostat cycles condenser fan and compressor heater to maintain room temperature at thermostat setting.
b. Low-ambient control to permit condensing-unit operation down to ambient temperature of 30F.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances within space provided and make readily serviceable.

B. Provide foundation, platforms and hangers necessary for proper installation of equipment.

C. Install equipment on concrete pads minimum of four inches in height in accordance with Section 03100, 03200 and 03300.

D. Ensure that fans operate without noticeable vibration after installation.

E. Arrange belt guards to permit use of tachometer, oiling and testing with guards in place.

F. Charge refrigerant in accordance with manufacturer's recommendations.

G. Electrical connections: Sections 16120 and 16130.

END OF SECTION

SECTION 15765

HEATING EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing heating equipment and electric heat tracing for piping.

B. Related Work Specified Elsewhere:
1. Vibration isolators: Section 15070.
2. Ventilating Units: Section 15725.
3. Control equipment: Section 15900.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. UL: 1025.

B. Source Quality Control:
1. Test electric heating coils dielectrically at 2,000 volts before shipment.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
2. Certification:
   a. Successful dielectric testing of electric heating coil at 2,000 volts.
3. Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors, starters and relays.

B. Electric Heating Coils:
1. Casings:
   a. Frame members, casings, terminal box, terminal-box cover and similar sheet metal parts fabricated of minimum 18-gauge, die-formed steel with integral corrosion-resistant coating.
   b. Casing assembled into rigid structure by means of welding or threaded fastenings.
   c. Flanged in-line heater for inclusion in duct or ventilating unit.
   d. Coil-section panels factory-insulated.
2. Heating element:
   a. Heating elements composed of individual flange-mounted, finned-tube heating elements with highest grade nickel-chromium alloy resistor wire centered within tubes and embedded in compacted insulating material.
   b. Flanges and fins permanently furnace-brazed to elements for rigid support and rapid heat transfer.
   c. Finned tubes of copper-plated or ceramic-coated steel.

1) Ceramic coating fired at minimum of 1,500F and capable of continuous resistance to corrosion without cracking, checking or spalling under operating conditions.

3. Controls:
   a. In accordance with Section 15900, with the following additional requirements:
      1) Heaters provided with built-in step controllers.
      2) Heaters of 30 kw or less with manufacturer's standard steps.
      3) Heaters larger than 30 kw having six equal steps.
      4) An automatic-reset, snap-action, thermal-overheat switch provided to instantly de-energize heating coil when safe operating temperatures are exceeded.
      5) Heating coil interlocked with fan to prevent energization of heating coil while fan is not running.

C. Electric Unit Heaters:
1. Factory-assembled unit heaters consisting of heating element, fan, fan motor, housing and outlet diffuser.
   a. Casings:
      1) Fabricated of galvanized steel or bonderized steel, factory-primed and finished with baked enamel.
      2) Parts rigidly stiffened to prevent vibration and to hold working parts in line.
      3) Casings for suspended-type units designed for direct attachment to hangers.
      4) Ceiling or wall-mounted, spring-type brackets furnished as necessary to support unit.
      5) Casings readily removable for access to interior parts.
      6) Adjustable horizontal vanes, arranged to give uniform air distribution without objectionable drafts.
   b. Fan and fan motor:
      1) Propeller fan directly connected to fan motor.
      2) Fan air throw: As shown.
      3) Fan factory-balanced dynamically and designed for quiet operation.
      4) Unit heater/fan motor: As standard with manufacturer.
      5) Each unit equipped with combination fan guard/motor support resiliently mounted to absorb motor vibration.
      6) Motor speed: 1,750-rpm maximum.
      7) Integral transformer where fan-motor voltage differs from line voltage.
   c. Heating element:
      1) Resistance wire of corrosion-resistant metal surrounded by finned metal sheath, interspace filled with ceramic material or magnesium oxide.
      2) Each heating element wired to built-in, line-voltage, automatic-reset, thermal-overheat protection.
      3) Complete controls, contactors, control-circuit transformers factory-assembled and factory-wired.
      4) Unit heaters tested and listed under UL 1025.
      5) Thermostats: Built-in, unless otherwise shown.
      6) Disconnect switch near unit heater.
   d. Unit heaters with capacities of 10 kW or higher equippped with H.O.A. switches.

D. Electric Wall Convectors:
1. Factory-assembled consisting of heating element, connection boxes, controls, surface-mounted steel cabinet and wall-mounted thermostat.
2. Convector cabinet: Fabricated of heavy-gauge reinforced steel with inlet and outlet grilles.

3. Surface-mounted cabinet, chemically treated to resist corrosion and finished in baked prime coat.
4. Cabinets equipped with disconnect switch and automatic-reset thermal-overload protection.
5. Heating elements of steel-sheath or aluminum-sheath enclosed construction, nonhumming, with fins permanently brazed to tube for quick and efficient heat transfer.
6. Heating elements having a nonoxidizing heat-resistant finish.
7. Completely factory-wired, tested and UL-listed.
8. Capacity and operating characteristics: As shown.

E. Electric Heat Tracing for Piping:
1. Heat-traced pipe insulated after installation of heating tape in accordance with Section 15080.
2. Heating tape with single or twin heating elements embedded in impact-resistant, high-dielectric refractory material, UL-listed and with stainless-steel exterior protective sheath acting as electrical ground in case heating element touches sheath.
3. Heating tape rated for voltage shown and capable of producing wattage shown.
4. Heating tape flexible with minimum bending radius of not more than six times diameter of tape.
5. Heating tape compatible with pipe temperature-sensing thermostat: Section 15900.
6. Heating tape connected to power source and controls through nonheating leads minimum seven feet in length.

F. Nameplates:
1. Securely attached to each major item of equipment showing manufacturer's name, model number and serial number.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances to space provided and make readily serviceable.

B. Mount electric unit heaters on vibration isolators in accordance with Section 15070.

C. Provide supports, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer

D. Provide heat tracing on piping where shown.

E. Install electric heating coil where shown.

F. Apply insulation on heat-traced piping in accordance with manufacturer's recommendations.
1. Where heating tape is spiralled, ensure that adjacent turns do not touch so as to avoid overheating and damaging sheath material.
2. Allow minimum of one inch between spirals.
3. Do not flex wire when ambient temperature is less than 32F, unless tape is warmed.
4. Connect unheated cold end to power source.
5. Secure heating tape in contact with pipe with banding or strapping.
6. Provide automatic temperature control by thermostat designed and set to energize at 40F.
7. Upon completion of installation and testing of pipe, install and test heating tape in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 15810

DUCTWORK

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing ductwork and accessories.

B. Related Work Specified Elsewhere:
   1. Firestopping; Section 07841.
   2. Insulation: Section 15080.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. SMACNA:
      a. HVAC Duct Construction Standards - Metal and Flexible.
      b. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
      c. HVAC Systems - Testing, Adjusting and Balancing.
      d. HVAC Air Duct Leakage Test Manual.
   3. ASTM: A36, A53, A653.
   4. NFPA: 90A
   5. AASHTO: M81.
   6. UL: Building Materials Directory, 181, 555.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Scale: 1/4-inch minimum
   2. Certification.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Galvanized Sheet Steel: ASTM A653.

B. Steel Plate: ASTM A36, Grade A.

C. Steel Pipe: ASTM A53, Grade A.

D. Flexible Material:
   1. Fibrous-glass cloth, 32 ounces per square yard, UL-listed.
   2. Tensile strength: 450-psi minimum.
   3. Coated on both sides with fire-resistant neoprene.
   4. Suitable for operating temperature of 200F and meeting requirements of NFPA 90A.

E. Paint:
   1. Zinc-rich gray, No. 721, Detroit Graphite or equal.
   2. Bituminous, AASHTO M81, Grade RC-250.

2.02 FABRICATION:

A. Duct Construction:
   1. Fabrication in accordance with HVAC Duct Construction Standards-Metal and Flexible.

B. Access Doors in Ducts:
   1. Provide access doors as shown to gain access to resistance heaters, fans, fan motors, dampers, filters, coils and controls.
   2. Doors: Of same metal thickness as ducts.
   3. Gasketed doors: Secured to duct.

C. Plenums:
   1. Field-fabricated and reinforced consistent with class of ductwork in which used.
   2. Outward-opening access doors to plenums provided where necessary for equipment access and as shown.

D. Embedded Ductwork:
   1. Fabricated of welded steel plate or round steel pipe. Minimum thickness for steel plate 1/4 inch. Minimum wall thickness for pipe 1/4 inch. For galvanizing, mask joint areas at ends of sections after fabrication.
   2. Hot-dip galvanized after fabrication, with minimum coating weight of two ounces per square foot. Where shown, inside of sections insulated as specified in Section 15080. Apply one coat of specified paint to exterior surfaces.

E. Expansion Joints in Embedded Ducts:
   1. Where ductwork crosses structural contraction joints at 90 degrees to plane of joint, provided slip-type expansion joints in ductwork at structural contraction-joint crossings.
   2. Provide expansion joints designed to accommodate linear movement at contraction joint.
   3. Provide slip-type expansion joint in perforated-metal duct liner

F. Dampers:
   1. Splitter or butterfly damper provided in duct leading to air terminal as shown.
   2. Butterfly dampers:
      a. Balanced-type with flat blades.
      b. Rigid blades fabricated with close-fitting hemmed edges.
      c. Damper rods minimum 3/8-inch square at one end passing directly through ducts.
      d. Square end of each rod held in self-locking lever device.
      e. Where installed in furred ceilings, damper-locking device may be provided with short lever and concealed in box with flush cover in lieu of access panel.
   3. Opposed-blade dampers:
      a. Gang-operated multiple blades provided in ducts over 12 inches in dimension.
      b. Multiple blades fabricated maximum six inches wide.
      c. Fabricated with nonmetallic edges or coating in low-pressure, medium-pressure or high-pressure ducts.
      d. Ends of damper rods sealed to prevent leakage of air.
   4. Splitter dampers:
      a. Single blade with hemmed edges, provided at branch duct connections.
      b. Each blade hinged at one end with sheet metal straps.

c. Free end of each blade connected to 1/4-inch adjusting rod secured to side of duct in flanged bushing with set screws.
d. Rods adjusted to operate freely between open and closed positions.

5. Damper material:
   a. Splitter and damper blades fabricated of same metal and two gauges heavier than ductwork and casings.
   b. Fastening details and other items fabricated of metal specified for ductwork and casing bracing.
6. Damper regulators:
   a. Self-locking, damper and splitter regulators furnished, labeled SHUT and OPEN.
   b. Factory-fabricated damper and splitter hardware furnished with zinc or cadmium protective coating.
7. Fire dampers:
   a. Fabricated to meet requirements of codes and regulations of jurisdictional authorities.
   b. Constructed so that, during normal operation, folded blade assembly does not interrupt air stream.
   c. Access provided for replacement of links.
   d. Sleeve provided for fire damper, 14-gauge hot-rolled steel.
   e. Fire dampers remote from fire partitions; connecting ductwork provided between fire damper and fire partition, fabricated of 11-gauge, zinc-coated sheet steel and supported by ½-inch diameter rods.
   f. Fire dampers constructed to meet requirements of NFPA 90A and UL 555.

G. Flexible-Duct Connections:
1. Flexible-duct connections provided between air-handling unit fan and related ductwork and wherever necessary to prevent transmission of vibration to adjacent elements.
2. Factory-assembled flexible material bordered each side with three-inch wide galvanized-steel edging mechanically attached.
3. Width of flexible portion: Three to nine inches as necessary for installation conditions and to allow freedom of movement without unnecessary slack.
4. Fabric parts of flexible connections: Unpainted.

H. Instrument Test Holes:
1. Factory-fabricated, airtight, non-corrosive instrument test hole with screw cap and gasket.
2. Instrument test holes provided where required by balancing and testing agency.
3. Cap extended up through insulation.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Ductwork Installation:
1. Install dampers and splitters so as to permit adjustment after completion of the work.
2. Install dampers without strain or distortion of any part of dampers.
3. Adjust moving parts to move freely without binding.
4. Caulk dampers airtight around frames.
5. Adjust damper and splitter adjusting rods to operate freely between open and closed positions.
   a. Cut off projecting ends of rods after adjustment and bend over two inches from bushings.
   b. Leave cut ends smooth and free from burrs.

6. Where diffuser is located at end of rectangular duct, extend duct minimum of one-neck diameter beyond center line of neck.
7. Fire dampers:
   a. Install fire dampers in ducts which penetrate walls or floors separating areas normally used by the public from ancillary areas. Patron-used areas include, but are not limited to, the following:
      1) Station train rooms.
      2) Train tunnels.
      3) Passageways ordinarily used by patrons.
   b. Install fire dampers in ducts which penetrate walls and floors of elevator machinery rooms.
   c. Install fire dampers to conform with fire, smoke and radiation damper installation guide for HVAC system
8. Embedded Ductwork:
   a. Join sections by continuous weld to achieve watertightness.
9. Duct penetration through fire-rated partitions to be sealed with approved fireproof sealant in accordance with Section 07841.
10. At in-line fans, provide flanged removable transition to permit access to and removal of fan motor

B. Flexible Connections:
1. Install flexible connections in accordance with HVAC Duct Construction Standards – Metal and Flexible.

C. Protection of Ductwork:
1. Protect ductwork, appurtenances and openings from dirt, foreign objects and damage during construction.
2. Replace damaged ductwork and appurtenances.
3. Provide sheet metal caps on duct ends that are to be connected to future ductwork.

D. Painting of Embedded Ductwork:
1. After pressure test, clean joint areas.
2. Coat outside of duct joints with zinc-rich paint measuring not less than five mils dry-film thickness or with two coats of bituminous paint over compatible primer.

3.02 FIELD QUALITY CONTROL:

A. Air-Leak Tests for Accessible Ductwork: Perform air-leak tests in accordance with SMACNA HVAC Air Duct Leakage Test Manual.

B. Air-Leak Test for Embedded Ductwork: Test ductwork with internal air pressure of six inches wg. In accordance with SMACNA.

3.03 CLEANING OF AIR SYSTEM:

A. Before fans or filters are operated, clean inside of air system, including casing, plenums, ductwork and concrete tunnels used for air supply or return.

B. Accomplish cleaning by means of industrial vacuum cleaners which will effectively remove dust and foreign material from surfaces swept by air stream.

C. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil and foreign material prior to application of insulation or finish painting.

D. Clean ducts after the system has been used for adjusting, testing or temporary ventilation.

END OF SECTION

SECTION 15830

FANS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing fans.

B. Related Work Specified Elsewhere:
1. Vibration isolation: Section 15070.
2. Ductwork: 15810.
3. Control equipment: Section 15900.
4. Motors: Section 16225.
5. Motor starters and control centers: Section 16425.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AISI Standards.
3. AMCA: 210, 99-2408.
4. NFPA: 130.
5. SAE: 1035,1040.

B. Factory Wiring:
1. In accordance with manufacturer's standard practice.

C. Source Quality Control:
1. Notify the Engineer 14 days prior to each test.
2. Tunnel ventilation-fan testing:
   a. Whirl tests:
      1) Perform tests on each fan at factory prior to shipment.
      2) Three tests total, each two minutes in duration, each performed at 125 percent of the operating rpm minimum.
   b. Fan-reversal tests:
      1) Operate fan in primary direction at rated rpm for five minutes minimum.
      2) Disconnect power for 20 seconds; start fan in reverse direction.
      3) Operate fan in reverse direction for five minutes minimum, disconnect power for 20 seconds and restart fan in primary direction.
      4) Operate fan in primary direction for five minutes minimum, disconnect power and allow fan to stop gradually.
      5) Record following data and submit with shop drawings:
         a) Motor-winding temperature and motor current, recorded continuously during test.
         b) Motor-winding electrical resistance, recorded immediately prior to and following test.
      6) After completion of testing, inspect hub and blades for surface defects with approved penetrant dye. Submit certification of visual acceptability of fan hub and blades.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Performance tests certified by AMCA or performed either in accordance with AMCA 210 or in a laboratory approved by AMCA, for capacities shown.
      b. Performance curves for each fan showing brake horsepower, static pressure and static efficiency plotted against air volume and noise level. For reversible fans, submit curves for both forward and reverse modes.
   2. Certification:
      a. For under-platform-exhaust fans, dome-exhaust fans and subway-ventilation fans, certify that fans are rated and tested in accordance with AMCA 210.
      b. For subway-ventilation fans, certify that sound power level based on 10^{-12} watts does not exceed decibel ratings, without attenuators as specified.
   3. Operation and Maintenance Manuals.

1.04 JOB CONDITIONS:

A. Safety Requirements:
   1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys and other rotating parts to prevent danger to personnel.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:
   1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors starters and relays.
   2. Requirements of this section apply to fans which are not a component part of air-handling units designed as complete units by the manufacturer.
   3. Fan rating based on tests performed in accordance with AMCA 210.
   4. Fans statically and dynamically balanced and quiet in operation.
   5. Fans designed to ensure that resonance frequency of blade assembly is not within 15 percent of harmonics of rotational frequency.
   6. Finished parts of fans, such as shafts and bearings, protected from rust prior to operation by means of wrappings or protective grease or plastic coatings.
   7. Exhaust fans, except subway-ventilation fans, under-platform-exhaust fans and dome-exhaust fans, provided with firestats to stop fan when temperature of air being handled reaches 125F.
      a. Firestat having adjustable range from 100F to 200F and manual reset.
   8. Fans with wheels less than 12 inches in diameter, and utility fans operating at less than 0.75 inches WG may have forward-curved blades.
   9. Fan construction suitable for operating conditions defined in AMCA 99-2408.

B. Centrifugal Fans:
   1. Class I or II, nonoverloading.
   2. Fan blades:
      a. Fan wheels larger than 30 inches: Backward-inclined air-foil section.
      b. Fan wheels 30 inches or less: Backward-inclined plate-type blades.
   3. Air entering fan uniformly over inlet area.
   4. Fan housing: Fabricated of steel sheets, manufacturer's standard heavy-gauge construction, except for those of low-pressure fans of less than 5,000-cfm capacity which may be fabricated of aluminum, 0.080-inch thick or heavier.

5. Fan wheel rims and blades: Fabricated of steel, manufacturer's standard heavy-gauge construction, with back plates of steel, 3/16 inch, except for those of low-pressure fans of less than 5,000 cfm which maybe fabricated of aluminum, 0.080-inch thick or heavier.
6. Fan wheels: Aluminum or steel provided with manufacturer's standard corrosion-resistant coating.
7. Fan scroll attached to the side plates by means of continuous lock-seam or welded-seam construction.
8. Fan wheels and sheaves splined or keyed and fastened to the shafts with set screws.
9. Shaft constructed solid or hollow of SAE 1035 or SAE 1040 ground and polished steel.
10. One layer of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.
11. Inspection openings provided for fan housing having wheels larger than 22 inches in diameter.
    a. Cover plate having pressure latches on fan housing on scroll sheets located opposite outlets.
12. Large fan housings provided in sections to permit installation or removal through openings available in structure.
13. Field joints: Flanged and bolted.
14. Fans designed to provide self-limiting, nonoverloading power characteristics.
15. Two bearings for double-inlet and single-inlet fans having wheels larger than 36 inches in diameter, one on each side of wheel, with overhung sheaves.
16. Inside and outside of fan housings factory-painted with baked-enamel primer; exterior surfaces given additional factory finish-coat of enamel.
17. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
    a. Adjustable sheaves furnished on motor, capable of 20-percent adjustment in fan speed, with design fan-capacity setting at approximately midpoint of adjustment.
    b. Drives provided with belt guard of expanded-metal wire mesh or belt guards with solid-metal side panels with tachometer opening.
18. Motors:
    a. One-half horse power and above: Totally enclosed, fan-cooled and guarded in accordance with Section 16225.
    b. Less than 1/2 horsepower: Manufacturer's standard for intended use.
19. Vibration isolators: In accordance with Section 15070.

C. Tubular Centrifugal Fans:
1. Class I or II, belt-driven, nonoverloading, designed for straight through airflow.
2. Housing: Manufacturer's standard heavy-gauge steel construction.
    a. Flanged inlet and outlet for connection to ductwork, with inlet and outlet identical in size.
    b. Welded, cylindrical construction, braced to prevent vibration.
    c. Fan bearings and drive enclosed and isolated from air stream.
3. Fan wheels:
    a. Welded construction, centrifugal wheel, with backward-inclined blades.
    b. Fan wheels 27 inches in diameter or larger supplied with double thickness, air-foil blades.
    c. Fan wheels less than 27 inches in diameter supplied with plate-type blades.
    d. Fan wheels statically and dynamically balanced.
4. Fans supplied with stationary conversion vanes on discharge side of wheel designed to reduce turbulence.
5. Fan bearings:
    a. Heavy-duty, self-aligning ball bearings.

b. Lubrication fittings extended to fan casing and provided with covers to effectively exclude water and dirt.

6. Fan shaft accurately machined and ground for proper fit to wheel hub and bearing and designed to operate well below first critical speed.
7. Inside and outside of fan housing factory-painted with baked-enamel primer. Exterior surfaces given an additional factory-coat of corrosion-resistant finish enamel.
8. One coat of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.
9. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
   a. Adjustable sheaves furnished on motor allowing 20-percent adjustment in fan speed, with design-capacity setting at approximately midpoint of adjustment.
10. Fan wheels and sheaves splined or keyed and fastened to the shaft with set screws.
11. Internal and external belt guards as necessary for complete protection.
12. Motors:
    a. One-half horsepower and above: Totally enclosed, fan-cooled and guarded in accordance with Section 16225.
    b. Less than 1/2 horsepower: Manufacturer's standard for intended use.

D. Axial Fans:
1. Direct-driven or belt-driven as shown.
2. Welded tubular-steel casings, except for low-pressure fans of less than 5,000-cfm capacity, which may have aluminum casings.
3. Equipped with stationary discharge conversion blades and adjustable motor mounts.
4. Air-foil blades: High-strength cast aluminum or steel.
5. Blade pitch:
   a. Fans with wheels 18 inches or larger: Blades field-adjustable without removing wheel from casing.
   b. Fans with wheels less than 18 inches in diameter: May be equipped with stationary blades.
6. Flanged-type for fan-casing connections to ductwork.
7. Internal and external belt guards, as appropriate.
8. Inlets with smooth, rounded edges.
9. Air entering and leaving fan axially.
10. Belt-driven fans:
    a. Provide with high-grade, open-hearth steel fan shaft accurately machined and ground for proper fit to wheel hub and bearings.
    b. Fan bearings and drive shafts enclosed and isolated from the air stream.
    c. Bearings sealed mechanically against dust and dirt, self-aligning and grease-lubricated.
    d. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
11. Motors:
    a. 1/2 horsepower and above:
       1) Belt-driven fans: Totally enclosed, fan-cooled and guarded in accordance with Section 16225.
       2) Direct-driven fans: Totally enclosed, air-over, fully guarded in accordance with Section 16225.
    b. Less than 1/2 horsepower: Manufacturer's standard for intended use.

E. Power Roof Ventilators:
1. Direct-driven or belt-driven as shown.
2. Consisting of fan with housing and weatherproof hood mounted on factory-supplied acoustical-thermal curb.

3. Fan housing constructed of spun aluminum and arranged to facilitate access for servicing from roof.
   a. Discharge openings with 1/2-inch wire-mesh bird screen of aluminum or provided with corrosion-resistant coating.
   b. Acoustical-thermal curb: Product of power roof-ventilator manufacturer.
   c. Aluminum-blade back-draft dampers sized to fit curb opening.
   d. Power roof-ventilator housing secured to curb to resist winds of 100 MPH.
4. Motor: Totally enclosed weatherproof housing located outside of air stream and as specified in Section 16225.
   a. Motor having unfused power-disconnect switch, mounted under fan housing adjacent to motor.
   b. Permanently sealed, grease-lubricated, ball bearings or roller bearings.
5. Belt-driven unit and belt drivers rated for 150 percent of motor-nameplate horsepower.
   a. Adjustable sheaves to permit 20-percent adjustment in fan speed, with design fan capacity at approximately midpoint of adjustment.
6. Wheel and drive assembly isolated from base section by means of rubber-in-shear isolators.

F. Propeller Fans:
1. Direct-connected or belt-connected, motor-driven.
2. Wheels having steel or aluminum blades; statically and dynamically balanced at the factory.
3. Cast or die-formed mounting rings or plates.
   a. Mounting plates designed to prevent distortion.
   b. Mounting plates turned up at edges or braced with steel angles.
4. Wire-mesh guard completely surrounding fan blades.
5. Steel shafts for fans which are not mounted directly on motor shafts.
   a. Shafts accurately finished on working surfaces.
6. Self-aligning sleeve bearings or ball bearings:
   a. Sleeve bearings:
      1) Ring oiled sleeve bearings or wool-packed and provided with oil reservoirs.
      2) Oiling device arranged in manner so that oil can be added while fan is running without danger of over-oiling.
   b. Ball bearings:
      1) Prelubricated sealed bearings.
      2) Factory-installed grease fittings to permit external bearing relubrication.
7. Motors:
   a. Up to and including 1/2 HP: Manufacturer's standard.
   b. Above 1/2 HP: Section 16225.

G. Under-Platform-Exhaust Fans and Dome-Exhaust Fans:
1. Tube axial, direct-driven, reversible.
2. Air volume in reverse: Minimum of 70 percent of that in forward direction.
3. Minimum efficiency: 75 percent at specified forward direction and operating conditions.
4. Brake horsepower: Not exceeding 100 percent of associated motor-nameplate rating at any point on fan power curve.
5. Construction:
   a. Fan housing constructed of minimum 1/4-inch welded steel plate, reinforced as necessary and flanged for connection to system ductwork or for mounting as otherwise shown.
   b. Wheel and motor entirely enclosed within fan housing.

c. Stationary curved guide vanes integrally welded with housing and located on discharge side of wheel to straighten motion of air leaving blades.
d. Fan wheels: Fabricated of high-strength cast aluminum or steel with air-foil shaped, adjustable blades.
e. Blades adjustable without removing wheel. Index and stops at hub to prevent overload of motor.
f. Positive-locking device installed for attaching rotor to motor shaft.
g. Drain fittings located in low parts of fan housing.
h. Fan fabricated of corrosion-resistant materials.

6. Fan motors: Section 16225, with the following additional requirements:
a. Totally enclosed, air-over, squirrel cage, induction, reversible, fully guarded.
b. Adequate cooling in both directions at 50 percent of flow.
c. Motor bearings precision-grade anti-friction type, packed at the factory with special lubricant designed for maximum radial and thrust loads to be encountered in both directions of air flow.
d. Double-shielded bearings, minimum 200,000-hour life, regreasable with readily accessible inlet grease fittings and outlet grease plug to allow for in-service greasing, and metering the amount of grease which actually enters the bearings to protect against over-lubrication.
e. Grease fittings brought to outside of fan housing and provided with covers which effectively exclude water and dirt between lubrications.
f. Each motor with a drain plug at bottom of shell.
g. Motor speed not to exceed 1,200 rpm.

7. High temperature: Fans and motors capable of meeting high temperature requirements specified in NFPA 130.

H. Subway-Ventilation Fans:
1. Tube axial, direct-driven, reversible, corrosion-resistant, designed for mounting in any position without modification.
2. Capacity:
a. Each subway-ventilation fan having forward direction and reverse direction capacity as shown when operating at total pressures shown.
b. Minimum efficiency: 75 percent at specified forward direction and operating conditions.
c. Brake horsepower: Not exceeding 100 percent of associated motor-nameplate rating at any point on fan power curve.

3. Construction:
a. Fan housing constructed of minimum 1/4-inch welded steel plate, reinforced as required and flanged for connection to inlet bells, outlet cones and outlet transitions provided by fan manufacturer.
b. Inside diameter of housing: 60 inches.
c. Wheel and motor totally enclosed within fan housing and not protruding at either end of housing exclusive of attached bells and cones.
d. Stationary curved guide vanes, integrally welded with housing and located on discharge side of wheel to straighten motion of air leaving blades.
e. Drain fittings located in low part of fan housing.
f. Inlet bell, outlet cone and outlet transition constructed of heavy-gauge, welded steel, flanged for connection to fan housing.
1) Outlet transition having not more than ten degrees divergence all around.
g. Fan wheels fabricated of high-strength cast aluminum or steel with air-foil shaped, adjustable blades.
h. Blades adjustable without removing wheel.
i. Positive-locking device installed in attaching rotor to motor shaft.
j. 3/4-inch square woven-mesh, galvanized-steel screen on inlet side of each fan.

4. Fan motors: Section 16225, with the following additional requirements:
   a. Totally enclosed, air-over.
   b. 900-rpm maximum.
   c. Motor bearings precision-grade, anti-friction bearings, factory-packed with special lubricant designed for maximum radial and thrust loads encountered in both directions of air flow.
   d. Double-shielded bearings, regreasable with readily accessible inlet grease fittings and outlet grease plug to allow for in-service greasing and metering amount of grease which actually enters bearings to protect against over-lubrication. In normal ambient conditions the bearings shall be designed for 200,000 hours operation services (L-50 life rating).
   e. Grease fittings brought to outside of fan housing and provided with covers to effectively exclude water and dirt.
   f. Each motor with drain plug at bottom of shell.
   g. Factory-installed resistance heater within motor enclosure.
      1) Resistance heater: Single-phase, 460 volt, 60 Hertz.
      2) Heater energized by means of NC auxiliary contact located in magnetic motor starter.
      3) Control sequence: Section 15900.
5. Sound ratings:
   a. Maximum permissible sound levels, based on 10-12 watts:

Octave Band Center Frequency/Hertz	Sound Power Level/dB
63	87
125	96
250	98
500	99
1000	99
2000	94
4000	91
8000	90

   b. If sound exceeds permissible levels, provide sound attenuators as specified in Section 15825.
6. High temperature: Fans and motors capable of meeting high temperature requirements specified in NFPA 130.

I. Jet Fans:
1. Constructed of corrosion-resistant materials and finishes.
2. Fan components and assemblies supplied by a single manufacturer. Parts interchangeable to the extent possible.
3. Capable of delivering same volume of air in both forward and reverse directions of airflow. Capable of reversing airflow a minimum of three times during any one-hour period.
4. Maximum vibrations are not to exceed a peak-to-peak amplitude of 2.0 mm for a normal operating speed of 1800 rpm or less.

5. Blade pitch manually adjustable without removing impeller. The maximum blade setting is to permit a minimum 15-percent increase in capacity above the design operating blade setting without motor overload or use of motor service factor.
6. Conforming to NFPA 130 and applicable ANSI, AISI, AMCA and ASHRAE standards.
7. Provided with fan support and suspension system designed per AISI Allowable Stress Design Method and which permits removal or replacement or both within a two-hour maintenance period.
8. Housing, motor mounts and supports fabricated of hot-rolled steel and of continuous-welded construction; minimum eight-gauge USSG thickness and capable of withstanding penetration forces from blade failure and rotating forces due to loss-of-blade imbalance.
9. Equipped with serviceable assemblies, including access doors of adequate size in the fan housing for inspection of blade locking devices and vibration devices and vibration test instrumentation. Doors of steel construction with AISI Type 316 stainless steel hardware and gasket material for the operating conditions as required.
10. Capable of starting and continuously operating at full capacity in ambient air temperature range of zero to 40 degrees Celsius.
11. Fan assemblies capable of operating at elevated temperatures as defined in NFPA 130.
12. Impeller designed to withstand the stresses and loads created by overspeed testing of 125-percent of the nominal operating speed.
13. Provided with adequate clearance between blade tips and housing at all points to allow for expansion and contraction over the operating and emergency temperature ranges.
14. Motors and motor assemblies are to conform to the following:
    a. NEMA Design B.
    b. Capable of accelerating the fan impeller from stand still to the rated rotational speed in less than 15 seconds when connected to the terminal voltage of 75-percent of the nominal supply voltage.
    c. Applicable ANSI, IEEE and NEMA or approved equivalent ISO standards.
    d. Minimum Class H insulation and Class F rating for temperature rise when tested at the service factor load.
    e. Totally enclosed, high efficiency, air-over, all cast iron or high grade silicone steel frame, induction type, wound for 480-volt, three-phase, 60-hertz alternating current.
    f. Bearings designed and constructed for maximum radial thrust loads anticipated during starting, operating and reversing conditions. Bearings are to have a minimum L-10 life rating equal to 40,000 hours as defined by the AFBMA.
    g. Equipped with 120-volt, single-phase heaters to prevent condensation in the motor windings.
    h. Bearing lubrication lines extending to the exterior of the fan housing and terminating in straight lubrication fittings; fittings provided with covers to exclude water and dust

J. Nameplates:
1. Fans: Securely attached on each fan showing manufacturer's name, model number and serial number.
2. Motors: As specified in Section 16225.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit fans and appurtenances within space provided and make readily serviceable.

B. Provide support beams, concrete pads, support legs, platforms, hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer.

C. Vibration isolation for fans: As specified in Section 15070.

D. Concrete pads: As specified in Section 15070.

E. Axial and tubular centrifugal fans: Provide service access in accordance with Section 15810

F. Motor starters and control centers: As specified in Section 16425.

END OF SECTION

SECTION 15850

OUTLETS AND GRILLES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing outlets and grilles.

B. Related Work Specified Elsewhere:
   1. Air conditioning pylons: Section 15806.
   2. System balancing and testing: Section 15950.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Samples:
      a. One full-size sample of each outlet and grille in each finish specified.
   3. Certification.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Supply Grilles:
   1. Type: Removable core, adjustable, two-way directional.
   2. Horizontal adjustment: By means of individually adjustable vertical bars or vanes spaced one-inch apart maximum.
   3. Vertical adjustment: By means of individually adjustable horizontal bars or vanes placed in front of vertical bars or by means of fixed fins which can be removed as a unit from frame and inserted in four positions.
   4. Horizontal bars or vanes spaced one-inch apart maximum.
   5. Fixed fins spaced 1/4-inch apart maximum.
   6. Frames constructed of stamped-steel or rolled-steel sections.
      a. Prior to priming and finishing, steel parts of grilles treated with zinc-phosphate or zinc-chromate, dipped after fabrication.
   7. Supply grilles provided with airtight felt, neoprene or plastic sealing strips at edges, designed to prevent leakage.
   8. Corner joints finished to provide neat, trim appearance.
   9. Each grille provided with factory-fabricated volume-control damper furnished by grille manufacturer.
      a. Volume dampers: Group-operated, opposed-blade, key adjustable.
      b. Volume adjustment: By inserting key through face of grille.
      c. Operating mechanism not projecting through grille face.
   10. Factory-fabricated multiple-blade extractors, furnished by grille manufacturer where shown.

a. Multiple-blade extractors: Air-deflecting and air-straightening type with blades spaced two inches apart maximum.

B. Exhaust and Return Grilles:
1. Exhaust and return grilles constructed as specified for supply grilles except with single set of nonadjustable face bars or vanes having same appearance as supply grilles.
2. Volume-control dampers where shown.

C. Ceiling Diffusers:
1. Types: Circular, square, rectangular or linear as shown.
2. Diffuser ring or frame: Compatible with ceiling construction in which they are installed.
3. Diffusers fabricated to meet sizes and capacities shown.
4. Transitions provided where necessary to connect ducts to diffusers.
5. Diffusers equipped with baffles or other devices necessary to achieve air-distribution pattern shown.
6. Turning vanes factory-fabricated, furnished by diffuser manufacturer, at each diffuser or takeoff except where flexible ductwork is used.
7. Single-key, opposed-blade volume damper factory-fabricated for each diffuser, furnished by diffuser manufacturer.
8. Diffuser constructed of steel or aluminum with edges exposed to view rolled or otherwise stiffened and rounded:
   a. Internal parts removable as unit to permit cleaning of diffuser and provide access to ducts.
   b. Removable parts constructed to prevent reassembly so as to produce incorrect air-distribution pattern.
   c. Internal assembly fastened to permit removal and reassembly without special tools.
9. Air-pattern control omitted from diffusers used for return air or exhaust air.
10. Air-duct or plenum connections secured to diffusers in accordance with manufacturer's recommendations.
11. Circular ceiling diffusers provided with two or more concentric circular elements designed to deliver air radially, in a generally horizontal direction.
12. Square and rectangular ceiling diffusers provided similar to circular diffusers, except that outer elements to be square or rectangular.
13. Where diffuser is located at end of rectangular duct, duct extended minimum one-neck diameter beyond centerline of neck.

D. Linear Air Diffusers:
1. Size and capacity: As shown.
2. Diffusers and components parts constructed of extruded aluminum and finished as specified.
3. Where diffuser length necessitates sectional installation, alignment slots provided for insertion of key strips or with other concealed means to align exposed butt edges of diffuser:
   a. Joints between diffuser sections to appear as hairline.
   b. Corner joints of frames and flanges exposed below ceiling or side wall to appear as hairline cracks with unexposed sides or corner joints welded or secured with alignment keys.
4. Air-delivery patterns: Manually adjustable from face of diffuser after installation.
   a. Full 180-degree air pattern, from horizontal left or right, vertical or intermediate pattern from each slot independent of other slots.
5. Damper blades:
   a. Independent of pattern blades.
   b. Damper designed for manual adjustment from face of diffuser.

6. Screws or bolts prohibited in exposed face of diffuser frames or flanges.

2.02 FINISHES:

A. Items exposed to public view in stations: Unless otherwise shown, factory-finished in baked enamel, colors as directed.

B. Items not exposed to public view: Factory-finished in light-gray baked enamel.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install grilles and diffusers to permit key adjustment from face without other special tools.

B. Install vanes and volume-control dampers to permit removal through diffuser for access to duct.

END OF SECTION

SECTION 15865

FILTERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing air filters.

B. Related Work Specified Elsewhere:
   1. Remote-surveillance devices: Sections 13810 and 15900.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. UL 900 Class 1.
   2. ASHRAE: 52.1.

B. Source Quality Control:
   1. Factory-tested or tested by an independent laboratory experienced in testing filters; certify compliance with requirements of ASHRAE Standard 52 for arrestance, efficiency, dust-holding capacity and pressure drop.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Certification.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:
   1. In design of equipment, provide for interchangeability of items of equipment, subassemblies, and parts.

B. Throwaway (Replaceable) Prefilters:
   1. Flat-panel filter units designed and fabricated for disposal when dust-load limit is reached.
   2. Dry or adhesive-coated filter media, as standard with the manufacturer.
   3. Maximum air flow through filters: Not exceeding manufacturer's published rated capacity but not exceeding 500 feet per minute at 0.10-inch w.g.
   4. Designed to fit within space available and constructed so as to prevent passage of unfiltered air.
   5. Filter frames constructed of 18-gauge galvanized steel with air-tight access panels for filter inspection, cleaning and replacement.
   6. Filters are UL 900 Class I listed.

C. Bag Filters:
   1. Horizontal air-flow filters of the high-density glass microfibers-type.
   2. Capacity based on air-handling capacity of unit to which it is applied with velocity limited to maximum of 500 feet per minute through filter based on net filter area.
   3. Provide high-density glass-microfiber filter media, reinforced with a backing to form a lofted filter blanket. Provide filter media with an average efficiency of 80 to 85

percent when tested by ASHRAE 52.1, and with an average arrestance of not less than 98 percent on that standard. Provide UL 900 Class 1 listed filters.

a. Remote-surveillance devices: In accordance with Section 13810 and Section 15900.

4. Pocket construction: Pockets to consist of glass microfibers chemically bonded to a reinforced UL Class 1 backing. Sew pockets with a tapered stitch which forms a V or wedge-shaped pocket resulting in uniform velocity in the passages of the air-entering and air-exiting sides of the filter. Equip the pockets with a minimum of 40 support points per square foot of filter media:
   a. Completely seal all stitching points with foam-seal or equivalent. Chemically adhere the pockets around the periphery of the galvanized-steel retainers. Provide retainers with rolled edges to reduce possible cuts to media, or lacerations to installers.
5. Enclosing frame: Construct enclosing frame of a J return channel of 16-gauge galvanized steel. The channel may be 7/8 inch or 1-1/8 inch.
6. Glide/Packs - for side-access applications: Factory fabricate and assemble filter housings. Construct the units of not less than 16-gauge galvanized steel, incorporating two access doors, extruded-aluminum tracks and individual universal holding frames designed to accommodate a wide range of standard size filters in varying efficiency ranges.
7. Leakage at rated airflow, upstream to downstream of filter, holding frame and slide mechanism to be less than one percent at 3-inch w.g. differential.
8. Leakage into housing from ambient atmosphere at rated airflow to be less than 0.5 percent at 3-inch w.g. negative. Manufacturer to submit substantiating test reports.
9. Construct access doors of 16-gauge galvanized steel and position them to facilitate removal and replacement of filters from either side of the housing. Equip each door with adjustable and replaceable post.
10. Provide factory installed 16-gauge galvanized steel transition plates on air-inlet and/or air-exit side to match air-handling unit.

D. Controls:
1. Control panels factory wired.
   a. Adjustable pressure-differential sensing device and wiring for remote surveillance.
   b. Pressure range of 0.02-inch w.g. to 1.0-inch w.g. Accuracy of plus-or-minus 0.03-inch w.g.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances within the space provided and make readily serviceable.

B. Install bag filters with capacities as shown.

C. Examine each bag filter's media before installation for seepage and adhesive to surface of container.

D. Replace bag filters showing evidence of seepage.

E. After final testing and cleaning of fans and ductwork, replace prefilters and final filter media with new, clean media.

END OF SECTION

SECTION 15900

CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing automatic temperature controls, remote surveillance and control and local control systems.

1.02 QUALITY ASSURANCE:

A. Qualifications of Manufacturer:
   1. Select manufacturer who maintains full-time organization for installation and service in the Washington, D.C. metropolitan area.
   2. Have instruments, piping and wiring installed by representative of temperature control-equipment manufacturer.

B. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM: A153.
   3. ASME: Boiler and Pressure Vessel Codes.
   4. NEMA: 250, ICS 2-1993
   5. UL: Electrical Construction Materials Directory.

C. Design Criteria:
   1. Automatic temperature-control systems:
      a. Design systems to perform functions and operate in sequence as shown or specified for air conditioning and ventilation of station platforms, mezzanines, station ancillary rooms, tie-breaker stations, traction-power substations and chilled-water plants.
      b. Maintain conditions shown or specified.
      c. Operate and control motor-operated dampers.
      d. Design duplex air compressor to have sufficient capacity to supply entire system, under normal conditions, while running less than 50 percent of the time.
      e. Design dessicant dryer system to maintain maximum pressure dew point of -10F at main air pressure and delivery volume necessary.
      f. Design control system to interface with fire and smoke-detection system by others to shut off the following fans on activation of fire and smoke-detection system.
         1) Battery-room fans:
         2) Air-conditioning and ancillary area fans in excess of 2,000 cfm, except the following:
            a) Underplatform-exhaust fans.
            b) Subway-ventilation fans.
            c) Dome-exhaust fans.
            d) Jet fans.
   2. Remote surveillance and control systems:
      a. Continuously measure parameters as shown including pressure, temperature and flow. Convert analog values of sensing transducer into seven-bit binary code and transfer to designated interface DTS terminals by relays.
      b. Monitor abnormal operations, such as high and low limits on pressure, temperature, water level, water flow, damper position, mode-selector switch

position and air flow as shown; provide contact closure to designated DTS terminals.

c. Design system to compensate for electrical losses in wiring. Design dc-power supplies and signal amplifiers, as necessary

D. Source Quality Control:

1. Test and stamp air storage tank in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Div. I.
2. Identify each transducer according to type, sensitivity, accuracy and operating range.
3. Each remote-indication system installed to have accuracy shown.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings:
   a. Complete catalog information and shop drawings for material and equipment including wiring and control diagrams.
   b. Submittals include, but are not limited, to the following:
      1) Air compressors, with motors and controls.
      2) Compressed-air storage tanks.
      3) Dessicant air drier system including prefilters, after each if provided, after filter.
      4) Thermostats.
      5) Controllers.
      6) Damper operators, electric or pneumatic as applicable.
      7) Automatic valves and operators.
      8) Dampers.
      9) Control panels and cabinets.
      10) Gauges and indicators.
      11) Transducers.
      12) Data-transmission system-interface relays.
      13) Sensing devices.
      14) Wiring diagrams, control diagrams and layouts for each system.
      15) Pneumatic controls.
      16) Control, indication and time-delay relays.
      17) Damper limit switches.
   c. Complete set of floor plans of rooms showing by means of graphic coding actual location and mounting heights of thermostats and zone served by each thermostat.
2. Operation and Maintenance Manuals:
   a. Complete electrical schematic of each system showing and identifying each internal and external component and internal and external wiring.
   b. Detailed piping and wiring diagrams showing graphic coding.
   c. Terminal numbers for wire or pipe connections.
   d. Complete parts list of internal and external components.

1.04 OPERATION AND MAINTENANCE TRAINING:

A. Upon completion of installation, furnish services of competent field engineer with specialized experience in temperature control and remote surveillance and control system to train Authority personnel in accordance with the General Requirements and as follows:

1. Instructional period: Three consecutive man-days minimum. A minimum of one day to be devoted to hands-on demonstration of the equipment operation, trouble analysis, repair, adjustment and maintenance.

2. Train operators in preventive maintenance of systems and to recognize malfunctions.
3. Provide complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of operating personnel.
   a. Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in system.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:
1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters, relays and transducers.

B. Automatic Temperature-Control System:
1. Air compressors:
   a. Duplex-type, with intake air cleaners of cleanable, impingement type, designed for heavy-duty service.
   b. Relief valve located between compressor and discharge shutoff valve, set for pressure 10-psi greater than that of control-switch cutout.
   c. Cast-iron or steel base for each compressor and motor for mounting on air tank or on separate concrete foundation.
   d. Controls:
      1) Enclosed, adjustable, pressure-operated pilot switches connected to motor starter and mounted on unloading device.
      2) To start lead compressor when air storage-tank pressure falls to 85 psig and stop it when pressure rises to 100 psig.
      3) To start lag compressor when air storage-tank pressure falls to 75 psig and stop it when pressure rises to 90 psig.
      4) Automatic alternator to change sequence of operation of compressors on completion of each cycle.
   e. Motors: Four-pole, dripproof and fully guarded: Section 16225.
2. Air storage tank:
   a. Construction: Welded steel plate designed for minimum of 125 psi in accordance with ASME Boiler and Pressure Vessel Codes.
   b. Finish: Zinc-coated after fabrication.
   c. Relief valve and automatic drain with drain piping extended to nearest drain.
   d. Tanks mounted with compressors: Horizontal or vertical.
      1) Tanks mounted separately: Vertical.
   e. Capacity: Such that idle time between compressor running periods is 10 minutes minimum.
3. Aftercooler:
   a. Air-cooled.
   b. Designed to reduce compressed-air temperature to a maximum of 100F.
   c. Operating pressure and temperature compatible with air compressor.
   d. Fabricated in accordance with ASME Boiler and Pressure Vessel Codes.
   e. Equipped with ASME PTC 25-3 safety valve.
   f. Built-in moisture separator with automatic drain valve.
4. Air dryer:
   a. Heatless/heaterless regenerative desiccant-type.
   b. Designed to supply air with a maximum pressure dew point of -10F at 80 psi and in sufficient quantity to operate controls as determined by controls contractor.

c. Two-tower design constructed in accordance with ASME Boiler and Pressure Vessel Codes.
d. Designed for a working pressure of 150-psi minimum.
e. Towers equipped with safety relief valves and pressure gauges.
f. Supplied as a complete package unit, operable on 115V, single-phase, 60-Hz power.
g. Rated in accordance with Compressed Air and Gas Institute (CAGI) Standard for Rating and Testing Compressed Air Dryers and National Fluid Power Association Recommended Standards.
h. Muffler on purge air discharge.
i. Fully automatic operation with cycle controlled by timer.
j. Electrical components including:
1) ON/OFF switch.
2) POWER ON light.

5. Prefilter:
a. Compatible with air dryer.
b. Automatic drain.
c. Coalescent-type.

6. Afterfilter:
a. Compatible with air dryer and designed to prevent desiccant carryover into compressed-air supply line.

7. Automatic valves:
a. Bodies, discs, stems and stuffing boxes designed for minimum working pressure of 125 psi.
b. Provide valves of type specified for each of the following body sizes:
1) 1-1/2 inches or smaller: Brass or bronze with screwed or union ends.
2) Four inches and larger: Iron bodies with brass or bronze trimmings and flanged ends.
3) Two inches to three inches: Brass or bronze with screwed or union ends or iron bodies with brass or bronze trimmings and flanged ends.
c. Visible position indicators and renewable discs.

8. Automatic dampers, except fan shaft, vent shaft and dome relief dampers:
a. Provided by automatic temperature-control manufacturer.
b. Factory-fabricated, opposed blade, balanced-type with factory-assembled linkages, mounted in galvanized-steel frames.
c. Blades: Flat or formed galvanized steel with interlocking edges or with compressible seals at point of contact.
1) Air-temperature range of seals: Suitable for operation from minus 20F to plus 200F.
2) Supported by thrust bearings for vertically mounted blades.
3) Length of blades between bearings: 48 inches maximum.
4) Width of blades: Eight inches maximum.
d. Leakage when closed: Maximum 20 cfm per square foot at static pressure of four inches water gauge.
e. Frames: Bar or channel, with corner bracing for rectangular dampers larger than four square feet in area.
f. Damper-operating linkage:
1) Adjustable-length galvanized-steel rods capable of withstanding load of at least twice maximum operating force of damper operator without deflection.
2) Joints: Brass pins and clevises or brass ball-and-socket joints.
g. Steel parts: Hot-dip galvanized after fabrication.

9. Automatic dampers for subway-ventilation fan discharge and bypass, vent shaft, underplatform-exhaust fan and dome-exhaust fan:

a. Automatic dampers factory-fabricated, constructed of galvanized sheet metal or extruded aluminum. Frames constructed of minimum 13-gauge galvanized sheet steel or extruded aluminum.
b. Dampers designed for control by pneumatic or electric motor operators. Mounting provisions for motor operators included in damper assembly.
c. Damper blades designed for air velocities to be encountered in system.
d. Blades: Maximum width eight inches and 24 inches maximum between bearings, fabricated of galvanized sheet steel, 16-gauge or double 22-gauge minimum.
e. Seals designed to withstand air temperatures ranging from minus 20F to plus 200F.
f. Damper-operating linkage:
    1) Adjustable-length galvanized-steel rods capable of withstanding without deflection load of at least twice maximum operating force of damper operator.
    2) Joints: Brass pins and clevises or brass ball-and-socket joints.
    3) Damper operators attached to operating linkage so as to ensure positive operation without lost motion.
g. Motor mounting supported so that operator will not deflect from its normal path when operating under load.
h. Steel parts: Hot-dip galvanized after fabrication. Galvanizing: 1.25 ounces, in accordance with ASTM A153.
i. Conforming to NFPA 130 high temperature requirements.

10. Pneumatic valve and damper operators:
    a. Spring-return type with nonferrous-metal bellows or reinforced-neoprene diaphragms.
    b. Bellows or diaphragm: Sized for operating pressure necessary to start valve or damper operator.
    c. Spring to return valve or damper to fail-safe position in event of power failure, in normally open or normally closed position as shown.
    d. Adjustment provisions: Adjustable stops to control open and closed positions of damper operators.
    e. Damper operators for vent-shaft dampers and fan-shaft dampers to include pilot or positive positioners.
11. Space thermostats:
    a. Supplied with subbase for mounting and guards as shown.
    b. Adjustment devices on controllers locked or concealed.
    c. Operating points: Minimum range 10 degrees above and 10-percent below operating points shown.
    d. Provide external thermometer with knob or lever-adjusting devices where shown.
    e. Thermostat throttling range: 2F maximum.
    f. Controllers, submaster controllers, lagged sensing elements and space thermostats provided with means for field adjustment of throttling range.
12. Duct thermostats:
    a. Remote sensing-element type, with controller mounted on apparatus control panel.
    b. Enclosure for operating and adjusting mechanism: Metal or phenolic-resin case.
    c. Thermostats used for freeze protection: Sensing element 20 feet minimum in length.
        1) Thermostat capable of operating when freezing condition exists at one-foot increments anywhere along sensing element.
    d. Remote transmitter provided when distance from bulb to panel exceeds manufacturer's recommended capillary length.
13. Pipe thermostats:

a. Immersion-type with liquid-filled separable sockets.
b. Remote sensing-element type, used where socket is located minimum five feet above floor.
c. Remote transmitter provided when distance from bulb to panel exceeds manufacturer's recommended capillary length.
d. Separable sockets: Stainless steel, heavy enough to withstand pulsations and turbulences in fluid controlled.
e. Pipe-sensing thermostat for electric heat tracing:
    1) Remote bulb suitable for attachment to outside of pipe as shown.
    2) Thermostat with DPST contacts, range of zero degree F to 100F and control differential of not more than 8F.
    3) Thermostat in NEMA 250, Type 4 enclosure, except NEMA 250, Type 12 enclosure for train tunnels, vent shafts or track-drainage pumping station.
    4) Contactor, as necessary, when total amperes of heating tape exceeds rated capacity of thermostat.

14. Pressure gauges:
    a. For individual-mounted controllers: Stem-mounted, two inches diameter minimum.
    b. For panel-mounted controllers, individual gauges: Two inches minimum diameter.
    c. For panel-mounted controllers, multiple-indication gauges: 3-1/2 inches minimum diameter.
15. Apparatus control panels, except for subway-ventilation fans and dome-exhaust fans:
    a. Separate apparatus control panel or metal cabinet for each air-handling and air-conditioning unit.
    b. Control instruments located on panel, except fire and freeze-protection instruments.
    c. Panel constructed of fire-resistant material with nonglare surfaces.
16. Electric damper operators:
    a. Spring-return type.
    b. Two-position motor operation.
    c. Spring returns damper to fail-safe position as shown in event of power failure or termination.
    d. Opening time: 60 seconds maximum.
    e. Adjustable stops to control open and closed positions.
17. Time clock:
    a. Suitable for automatic weekly switching operations of electrical equipment.
    b. Seven-day cycle with ten-hour spring reserve to maintain programmed switching in event of power failure.
    c. Capable of being programmed as desired.
    d. Manual trip mechanism for overriding timer.
    e. Mechanism powered by single-phase synchronous motor from available internal control power of 120 volts, 60 Hertz.
    f. Motor capable of operating at temperatures ranging from zero degrees F to 120F.
    g. Contacts of cadmium alloy, rated for 40-ampere, noninductive service at 120, 208/240, or 277 volts.
    h. Enclosure: NEMA 250, Type 1, surface-mounted.
18. Selector switch, except for subway-ventilation fan, underplatform-exhaust fan and dome-exhaust fan:
    a. Positions labeled HAND/OFF/AUTOMATIC.
    b. Maintained contact.
    c. Oil-tight.

d. Contact-rating designation: NEMA ICS 2-1993, with the following additional requirements:
1) Continuous current rating: 10 amperes.
2) Voltage rating: 120 volts, 60 Hertz

19. Damper limit switch:
a. Contacts: Single-pole; one NO, one NC; snap-action.
b. Enclosure: NEMA 250, Type 1.
c. Actuator: Level-operated, rotary-type, adjustable, with spring return.
d. Mounting: Plug-in type with receptacle tapped for conduit size as shown.
e. Contact-rating designation: NEMA A600, with the following additional requirements:
1) Continuous-current rating: 10 amperes.
2) Voltage rating: 120 volts, 60 Hertz.

20. Automatic alternator:
a. Equipped with ratchet mechanism to alternate opening and closing of two contacts after each ventilating-unit cycle.
b. Electrical requirements:
1) Continuous-current rating: 10 amperes.
2) Voltage rating: 120 volts, 60 Hertz.
3) Enclosure: NEMA 250, Type 1.

C. Remote Surveillance and Control:
1. DTS Relays:
a. Energized from command-center control via DTS.
b. Momentary-pulse type requiring no sustained power consumption.
c. Maximum coil load: 15 volt-amperes, resistive or suppressed inductive.
d. Coil voltage: 28 volts dc.
e. Contacts: Compatible with equipment controlled.

2. General relays:
a. Control and indication relays:
1) Functional designations and schematic connections as shown.
2) Number and configuration of contacts as shown.
3) Contact ratings:
a) Maximum switched voltage: 600 volts ac
b) Maximum continuous current: 10 amperes.
c) Capable of making load of 720 volt-amperes ac.
d) Capable of breaking load of 720 volt-amperes ac.
e) Minimum open-contact resistance: 50 megohms, 400 volts dc.
f) Maximum duration of bounce: 50 milliseconds.
4) Modular convertible contacts enclosed in plastic.
b. Time-delay relays:
1) Functional designations and schematic connections as shown.
2) Number and configuration of contacts as shown.
3) Capable of operating from minus 20F to plus 165F.
4) Externally adjustable time delay.
5) Contact rating:
a) Current capacity of 20 amperes resistive at 120 volts ac for 100,000 operations.
6) Insulation resistance: 50 megohms at 500 volts dc.
7) Auxiliary contacts for instantaneous transfer or two-step timing as scheduled.

3. Transducers:
a. Rise time: One-second maximum.
b. Sensitivity: Constant over operating range shown.

c. Adjustment for high and low operating ranges: Manual, calibrated and clearly identified.
d. Output: Accommodate three wires, marked with PLUS, MINUS and GROUND SHIELD symbols.
e. Transducers requiring external electric power to operate at 120 volts, single-phase, 60 Hertz.
f. Transducers requiring external air supply to operate from 20-psi source.
g. Housings: Moisture proof and disproof enclosure suitable for environment in which each transducer is located. Transducer nameplate attached to housing.

4. Drainage pumping-station surveillance:
   a. Indicating malfunction upon loss of electric power from both sources.
   b. Indicating malfunction when both pumps are running.
   c. Indicating malfunction when water level is above or below preset range.
5. Fan control cabinets:
   a. For subway ventilation-fan controls: NEMA 250, Type 4 steel enclosure with epoxy powdered-resin-coated finish.
   b. For underplatform exhaust-fan and dome exhaust-fan controls: NEMA 250,Type 1 enclosure.
   c. Mode-selector switch mounted in front cover:
      1) Maintained contact.
      2) Oil-tight.
      3) Contacts conforming to NEMA ICS 2-1993 rated for 10 amperes continuous current at 120 volts, 60 Hertz.
   d. Positions of mode-selector switch: Labeled on nameplate as follows: REMOTE/OFF/LOCAL EXHAUST/LOCAL SUPPLY.
   e. Complete electrical schematic diagram of control cabinet affixed permanently to inner surface of front cover and protected by clear Lucite.
      1) Include on schematic diagram parts list for all components of panel and contents, showing complete manufacturer's name, nomenclature and parts number
   f. Pilot lights mounted in front cover.
      1) Polycarbonate lens.
      2) Push to test.
      3) Legend plate with mode indicated.
      4) 20,000-hour 6.3-volt lamp.
   g. Control panel surface, except for underplatform-exhaust fans and dome-exhaust fans, lighted by fixture permanently mounted on panel.
      1) Fixture to include fireproof lampshade extending width of panel.
      2) Average lighting level: 40 foot-candles over entire surface of panel.
   h. Panel constructed of fire-resistant material with nonglare surface
6. Flow sensor:
   a. Diaphragm differential sensor.
   b. Single-pole, double-throw, snap-acting switch, 10-ampere rating.
   c. NC contacts.
   d. Adjustable set point.
   e. Operating range of zero degree F to 180F.
7. Electric heat tracing: Section 15725.

D. Traction-Power Substation Ventilating-Unit Controls:
1. Two-stage thermostat and automatic alternator.
2. Control sequence:
   a. When room temperature rises to 80F: Open lead-fan dampers and start lead fan.
   b. When room temperature rises to 90F: Open lag-fan dampers and start lag fan.

c. Reverse control process on falling temperature.
d. Automatic alternator reverses lead-lag sequence after each lead-fan operating cycle.

3. Selector switch.

E. AC Switchboard Room Ventilating-Fan Controls:
1. Thermostat, flow switches, time-delay relay, selector switch, automatic alternator and limit switches.
2. During each operating cycle, one fan to serve as primary fan and second fan as standby.
3. Control sequence:
a. Dampers on intake and discharge side to remain open when fans are not in operation.
b. When room temperature rises to 90F, relief damper(s) open, standby-fan intake damper closes and primary fan starts.
c. Control sequence to reverse when room temperature falls.
d. After each operating cycle, automatic alternator to reverse functions of automatic and standby fans.
4. Abnormal operation: If primary fan fails to operate, primary-fan intake damper closes, standby-fan intake damper opens and standby fan starts. Relief dampers to remain open during standby-fan operation.

F. DC Breaker Room and Tie-Breaker Station Ventilating-Fan Controls:
1. Single-stage space thermostat.
2. HAND/OFF/AUTOMATIC switch.
3. Operation:
a. Hand: Fan running, dampers open.
b. Off: Fan off, dampers closed.
c. Automatic:
1) When room temperature rises to 90F, open dampers and start fan.
2) Reverse control process on falling temperature.

G. Battery Room Fan Controls:
1. Battery room exhaust fan to operate continuously.
2. Magnetic starter.

H. Fire Alarm for Shutdown Interface Box: Data transmission system (DTS) cabinet specified in Section 16130, with the following additional requirements:
1. Cabinet: Hoffman A161206LP.
2. Terminal strip: Terminal as required mounted in upper right-hand quadrant of cabinet.
3. Exterior finish color: Sherwin-Williams Fire Protection Red.
a. Yellow letters, one-inch high on cover: FA-FAN SHUTDOWN.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances within space provided and make readily serviceable. All gauges and indicators to be installed so they can be readily read without use of ladder or other means to reach installed items.

B. Foundations, platforms, or hangers for apparatus in accordance with Sections 03200 and 03300.

C. Unless specifically shown otherwise on drawings, provide a complete compressed-air system as required for pneumatic-control system being provided, including air compressor, storage tank, pressure-reducing valves, aftercooler, air dryer complete with prefilter and afterfilter, and all control-air piping from air compressor to controls and operating units. Piping is to be in accordance with Section 15205.

D. Install 18AWG minimum control wiring, as shown and in accordance with Sections 16120 and 16125.
   1. Identify each wire at interface cabinet locations.
   2. When communication fan-shutdown interface cabinets are installed by others, complete wiring to designated terminals.

E. Automatic Temperature-Control Systems:
   1. Install entire automatic temperature-control system, including piping and wiring under supervision of automatic temperature-control equipment manufacturer.
   2. Mount damper operators outside of duct or casing with support plates that are completely outside insulation or covering.
      a. Install support plates so as to prevent condensation on damper operator or on supports.
   3. Support valves and damper-operator motor mountings so that operator does not deflect from its normal path when operating under load.
   4. Locate sensing elements of duct thermostats where they will respond to representative temperature within duct or casing.
   5. Duct thermostats and remote transmitters:
      a. Install outside of ducts and casings.
      b. Where ducts or casing are insulated, mount thermostats flush with outside insulation, so that moisture will not condense on thermostats or on supports.
   6. Duct thermal capillary tubes and wires:
      a. Install to pierce thermal insulation at least practicable number of points.
      b. Seal insulation properly where capillaries and wiring pass through.
   7. Capillary tubes:
      a. Protect by conduit, molding or flexible armor.
      b. Coil capillary tube neatly and fasten excess lengths out of the way.
   8. Apparatus control panel:
      a. Mount bottom of each panel 30 inches above floor.
      b. Provide 30 inches clearance between rear of panel and wall where conduit or wiring enters panel from rear.
      c. Mount controls, instrument gauges, thermostats and relays flush on front of panel.
      d. Install wiring and tubing connections for accessibility in servicing.
   9. Apparatus control cabinets:
      a. Make wiring and tubing connections to control instruments, indicating instruments and communication equipment inside cabinet.
      b. Install pilot lights, manual switches, and pushbutton controllers in cabinet door, so they are visible and operable with door closed.
   10. Mount framed schematic temperature-control diagram adjacent to each apparatus control panel or cabinet.
   11. Mount time clock on control panel in accordance with manufacturer's recommendations.
   12. Mount selector switch in motor-starter enclosure of ventilating units in ac-switchboard rooms, traction-power substations and tie-breaker stations.
   13. Mount pushbutton station in motor-starter enclosure of exhaust fan in battery rooms.
   14. Limit switch:
      a. Mount on automatic damper blades in ac-switchboard rooms, traction-power substations, tie-breaker stations, vent shafts, fan shafts, underplatform-exhaust fans and dome-exhaust fans.

b. Set switch contacts to close when damper opens.

15. Install automatic alternator in ac-switchboard rooms and traction-power substations which have two ventilating units.
16. Pipe-sensing thermostat for electric tracing:
    a. Firmly attach remote bulb against pipe at location in which bulb does not touch heating tape.
    b. Mount thermostat securely on wall at conveniently accessible location.
17. Install pneumatic-control systems for the following:
    a. Chilled-water plant.
    b. Underplatform-exhaust fans.
    c. Subway-ventilation fans and vent shafts where control air is available.
    d. Mezzanine and platform air-conditioning units with chilled-water coils.
    e. Dome-exhaust fans.
18. Install electric-control systems or functionally equivalent pneumatic-control systems for the following:
    a. Station ancillary-room heating, ventilating and air-conditioning systems.
    b. Traction-power substation and tie-breaker station ventilation systems.
    c. Subway-ventilation fans where control air is not available.
19. Install flow sensor in designated fans as shown and adjust to open or close contacts as shown at full flow in respective directions.

F. Remote Surveillance and Control:
1. Coordinate design with the Engineer and provide necessary interface for complete compatibility with DTS system.
2. Coordinate with the Engineer installation of fire-alarm sensors in air units.
3. Locate temperature-sensing transducer supervising space temperature in chilled-water plant adjacent to space thermostat.
4. Locate passenger-station temperature-sensing transducers adjacent to platform thermostat. Coordinate locations with the Engineer.
5. Provide shielding for sensing and signaling systems to prevent electrical interference.
6. Install flow sensor in designated fan as shown and adjust to close contacts at full flow in respective directions.

G. Fire-Detection Controls:
1. Coordinate enclosure interface terminal block with the Engineer.

H. Post diagrams under Lucite with aluminum-channel frames, waterproof glass-fiber backing adjacent to apparatus control panels.

3.02 FIELD QUALITY CONTROL:

A. Acceptance Testing:
1. Furnish equipment required to perform tests.
2. Submit test procedure for approval.
3. Perform approved tests to verify that control surveillance systems comply with requirements shown and specified.

END OF SECTION

SECTION 15950

SYSTEM BALANCING AND TESTING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies balancing, adjusting and performance-testing of heating, exhaust, air-conditioning and ventilating systems with ductwork. Water-balancing required only for chilled-water systems.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. NEBB: Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
   2. ASHRAE III: Practices for Measurement, Testing, Adjusting and Balancing of Building HVACR Systems.

B. Instrument Calibration:
   1. Calibrate instruments required for air and water balance within six months prior to use on this project.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Test and instrument location plans.
      b. After initial balancing measurements, submit shop drawings for additional equipment such as balancing dampers, pressure taps and balancing cocks necessary to effect proper air and water balance.
   2. Certification:
      a. Complete air and water-balance report certified by professional engineer licensed in the jurisdiction where the work is to be performed. Water balancing and testing includes entire system served by chiller plant in this project.
      b. Collect data in accordance with referenced standards.
      c. Submit complete data on standard NEBB testing and balancing report forms without omissions or on approved report forms bearing identical data. Data to include types, serial numbers and calibration dates of instruments and to cover the following:
         1) Air-conditioning units: Sections 15733, 15735 and 15737.
         2) Ventilating units: Section 15725.
         3) Fans: Section 15830.
         4) Electric heating coil: Section 15725.
         5) Ductwork including transverse and pilot tube test: Section 15810.
         6) Air outlets: Sections 15850 and 15806.
      d. In addition, provide the following data:
         1) Air-conditioning supply registers for side platform stations: Three temperature and velocity traverse perpendicular to coffer wall. Traverse consists of simultaneous readings at the following locations:
            a) Three readings five feet above platform, one each at three feet, five feet and nine feet from train edge of platform.
            b) One reading at face of register.

c) One reading twelve feet above edge of platform.

2) Air-conditioning pylons: One temperature and velocity traverse at each air-conditioning pylon. Traverse consists of simultaneous readings at the following locations:
   a) Twenty readings five feet above platform or mezzanine, one each at three feet, six feet, nine feet, twelve feet and fifteen feet from pylon, at each of four quadrant points around pylon.
   b) Four readings at supply register one at each of four quadrant points.
   c) One reading twelve feet above platform or mezzanine, three feet from pylon.

3) Air-conditioning supply registers for mezzanines: One temperature and velocity traverse at centerline of each coffer mezzanine supply register. Traverse consists of simultaneous readings at the following locations:
   a) Five readings five feet above mezzanine or escalator, one each at three feet, six feet, nine feet, twelve feet and eighteen feet from parapet or on escalator centerline.
   b) One reading at face of register.
   c) One reading twelve feet above mezzanine parapet at centerline of station.

e. Water-balance test reports to include data covering the following:
   1) Chilled-water coils: Section 15734.
   2) Chillers: Section 15625.
   3) Cooling towers: Section 15640.
   4) Pumps: Section 15185.
   5) Control valves: Section 15900.

PART 2 - PRODUCTS

2.01 Provide, as specified in Sections 15810 and 15205, additional equipment, such as balancing dampers, pressure taps and balancing cocks necessary to effect proper air and water balance.

2.02 Design, construct and install necessary blanking baffles for air-conditioning pylons.

PART 3 - EXECUTION

3.01 BALANCING AND PERFORMANCE TESTING:

A. After completion of installation of heating, exhaust and air-conditioning systems, and prior to acceptance by the Engineer, adjust and balance air-handling systems, water systems and appurtenances applicable to those systems to deliver the air and water quantities as specified and as shown. Make final tests after modifications are completed. Seal instrument test holes upon completion of balancing operation.

B. Air and Water Balance:
   1. Perform testing in accordance with referenced NEBB Standard, ASHRAE 111 or other approved standard.
   2. Perform tests, adjust and balance when outside conditions approximate design conditions as shown for heating and cooling functions.
   3. Balancing cock: Provide reference mark to permit reset after shutoff.

END OF SECTION

A. Grounding and Bonding Equipment:

1. General Requirements:
   a. UL 467.
2. Ground rods: Solid steel, with stainless steel or copper jacket, one-inch or 5/8-inch diameter as shown, by 10 feet long or of necessary length in 10-foot sections.
3. Grounding conductor:
   a. Grounding electrode conductors:
      1) Insulated or bare conductor, as shown, in accordance with the following:
         a) Insulated conductor: As specified in Section 16120 for single-conductor cable.
         b) Bare conductor: Section 16120.
      2) Size:
         a) For use in ground grid and for connecting of ground grid to ground bus: 4/0 AWG.
         b) For connection of ground bus in train-control, communications, electrical, dispatcher, Bell system and mechanical rooms to main ground bus in ac-switchboard rooms: 2/0 AWG.
         c) For other grounding electrode conductors: In accordance with NEC Table 250-66.
   b. Equipment grounding conductor:
      1) Sized in accordance with NEC Article 250-122 unless otherwise shown.
      2) Insulated equipment grounding conductor: Single-conductor cable as specified in Section 16120.
      3) Bare equipment grounding conductor integral with multiple-conductor cable: Section 16120.
   c. Bonding conductor for stray current and cathodic protection and electrical continuity:
      1) Insulated or bare conductors, as shown, in accordance with the following:
         a) Insulated conductors: As specified in Section 16120 for single-conductor cable.
         b) Bare conductor: Section 16120.
      2) Size: As shown or as specified.
4. Bus bar: ASTM B187-00, 98-percent-conductivity copper bus bar, size two inches wide by 1/4-inch thick, length as necessary.
5. Terminal lugs:
   a. For 4/0 AWG and smaller conductors: Copper compression terminal lugs.
   b. For 250 MCM and larger: Long-barrel, copper, double-compression terminal lugs.
6. Ground connector:
   a. O-Z, Type KG or equal.
   b. Two-piece, designed for connecting grounding conductor to bus bar.
   c. Copper-alloy body and silicon-bronze bolt, nut and lock washer with interlocking clamp.
7. Jumpers: Copper braided or leaf-type flexible jumper, size as necessary.
8. Bus-bar insulators: Fiberglass reinforced-polyester insulator with ½-inch diameter threaded holes at both ends for bus-bar installation.
9. Exothermic welded electrical connections:
   a. Exothermic process using powdered metals contained in a mold to form a molecular bond between materials to be connected without application of an external source of heat or power in accordance with ANSI/IEEE 80-2000.

b. Molds, weld metal and associated accessories designed for making electrical connections between copper and copper, copper and steel, copper and cast iron and copper and ductile iron as required.

c. Welding system designed for making connections suitable for the application as follows:
   1) Connections made outdoors for grounding using the standard process and not containing phosphorous or any caustic, toxic or explosive materials.
   2) Connections made indoors or in confined spaces for grounding using a low-smoke, low-emission process.
   3) Connections made specifically for cathodic protection applications using the standard process.

d. Molds made of graphite with permanent marking indicating name of manufacturer, model, conductor size, and type and size of welding mixture compatible with the welding process. Mold connection type suitable for making connections between various configurations of items as shown or specified.

e. Weld metal consisting of copper oxide and aluminum contained in a moisture-resistant container along with other necessary materials required for the specific application as determined by the manufacturer. Container for applications other than low-smoke, low-emission process to also include suitable starting material.

f. Container for weld metal identified with part number, type of metals to be connected and application such as standard outdoor, low emission or cathodic application.

PART 3 - EXECUTION

3.01 GROUNDING:

A. Ground Connections:
   1. Weld buried ground connections exothermically, in accordance with manufacturer's recommendations. Clean and coat with coal-tar epoxy before backfilling. Encapsulate with epoxy resin buried ground connection of grounding electrode conductors running to ground bus.
   2. Use terminal lug to connect grounding conductor to equipment enclosure. Use ground connector to connect grounding conductor to ground bus. Secure connector or terminal lug to the conductor so as to engage all strands equally. Install terminal lug using tools and pressure recommended by the manufacturer. Indent mark terminal lug with the number of die used for installation.
   3. Exothermically weld connections to ground rods in handholes, junction boxes and manholes, frame columns of bus passenger and bus supervisor shelters and station entrance pylon (type B) and light poles.
   4. Splices in grounding conductor are prohibited.
   5. For making ground connections located indoors and in confined spaces located outdoors such as manholes, use exothermic welds with low-smoke, low-emission process.

B. Ground Grid:
   1. Install ground grid consisting of ground-grid conductors and ground rods buried in earth in pattern and at locations shown.
   2. Use ground rod one-inch in diameter by 10 feet long or of greater length in 10-foot sections as shown.
   3. Bury top of ground rod 24 inches minimum below unfinished surfaces.

4. Ensure 24-inch minimum separation between ground rods or bare grounding conductors and concrete structures or soldier piles bonded for stray current and cathodic protection.
5. Interconnect ground rods using 4/0 AWG insulated or bare grounding conductor as shown.
6. For connecting ground grid to ground bus in associated traction-power substation and ac-switchboard room, provide minimum of four 4/0 AWG insulated grounding electrode conductors as shown.
7. For connecting ground grid to ground bus in dc tie-breaker station, chiller plant, fan shaft and drainage-pumping station, provide two 4/0 AWG insulated grounding electrode connections.
8. For additional grounding of service transformer in outdoor location, provide one grounding electrode conductor from nearest ground grid to transformer pad.
9. Unless otherwise shown, leave pigtail, three-feet six-inches minimum length, above finished floor for connection to ground bus or service-entrance equipment.
10. When ground grid is provided for electrical room, connect ground grid to ground bus in electrical room with two 4/0 AWG insulated grounding electrode conductors.

C. Ground Bus:
1. Install ground bus bar, two inches wide by 1/4-inch thick, around the inside periphery of traction-power substation, dc tie-breaker station, ac-switchboard room and electrical rooms; on full length of wall adjacent to service equipment such as switchboard and motor controls in chiller plants and mechanical rooms.
2. Install ground bus bar, two inches by 1/4 inch by 24 inches long in train-control, communications, dispatcher, Bell system and mechanical rooms, kiosk, fan shafts, drainage-pumping stations, escalator pits, elevator rooms, battery rooms and where shown.
3. Mount ground bus bar on insulators two feet above finished floor, unless otherwise shown, using cap screws and expandable threaded anchor.
4. Provide insulator support at each end of ground bus and at three-foot intervals.
5. In traction-power substation, dc tie-breaker station, ac-switchboard room, chiller plants, fan shafts, and drainage-pumping station, connect the ground bus to 4/0 AWG grounding electrode conductor running from associated ground grid.
6. In train-control, communications, electrical, dispatcher, Bell system and mechanical rooms, escalator pits, elevator rooms, battery rooms and other locations shown, connect ground bus to main ground bus in associated ac-switchboard room, traction-power substation or dc tie-breaker station, using 2/0 AWG insulated conductor.
7. Install 4/0 AWG insulated ground conductor, sub-ground bus, with one end connected to ground bus in ac-switchboard room, at following locations:
    a. In each tunnel for mainline track, support grounding conductor on channel inserts in tunnel wall.
    b. In each cable trough and ductbank along mainline track, install grounding conductor in cable-trough area and conduit reserved for ac power.
    c. In each cable space under station platform, install grounding conductor on channel inserts on wall.
8. Installing grounding connections in train-control and communication rooms:
    a. The only ground connection on the bus bar provided for train control and communication equipment grounding is the cable leading to the A. C. Switchboard room.
    b. Do not bond equipment or metallic structure to the ground bus provided for train control equipment.
    c. For items requiring bonding, have the bonding conductors go to the nearest ground bus beyond the ground bus provided for train control equipment.
    d. Grounding transformers to the dedicated train control and communication room ground bus bars is not permitted.

D. Equipment Grounding Conductor: Provide insulated equipment grounding conductor for following services and as shown:
   1. Feeders.
   2. Branch circuits.

E. Grounding of Service Equipment:
   1. Ground in accordance with NEC.
   2. Ground enclosure and ground bus in switchgear, switchboard, motor-control center or panelboard to ground bus provided in substation or room using insulated grounding electrode conductor.
   3. Install copper bonding jumper between neutral and ground bus as shown.

F. Grounding of Separately Derived AC System:
   1. Ground in accordance with NEC.
   2. Ground secondary neutral and enclosure of transformers to nearest ground bus or sub-bus using insulated grounding electrode conductor.
   3. For transformer located outside of building, install additional grounding connector between transformer secondary neutral/enclosure and ground bus or grid using insulated grounding electrode conductor.

G. Grounding for Personnel Safety:
   1. In substation, electrical and mechanical rooms, tie-breaker stations, chiller plants, fan shaft and pumping stations, bond exposed metallic structure, motor frame, ac-equipment enclosure, ductwork and metallic piping to local ground bus, using minimum of 6AWG insulated grounding conductor as follows:
      a. Ground multiple items of exposed metallic structure to local ground bus using a separate grounding conductor for each item or by using series-connected grounding conductors to connect two or more items.
      b. Ground each ac equipment enclosure to local ground bus using a separate grounding conductor.
      c. Connection of grounding conductor for ac equipment enclosure in series with grounding conductor for exposed metal structure is prohibited.
   2. Bond escalator's and elevator's motor frames, ac-equipment enclosures and metallic structures to equipment grounding conductor in ac-power feeder and to local ground bus bar. Provide a second ground path, connecting trusses and guide rails, using a #1/0 AWG insulated ground conductor connected to ground bus bar in A. C. Switchboard room. Leave 20-foot length of conductor coiled up in pits or wellway for making the grounding connections to trusses and guide rails by the escalator stage contractor.
   3. Bond metallic ladders and stairs in fan shafts, vent shafts and other locations to local ground bus, using insulated grounding conductor, 6AWG minimum.
   4. Bond and ground exposed metallic structures in open areas to separate grounding electrode in accordance with the following requirements:
      a. Metal pole for mounting light fixtures: Bond and ground each metal pole to separate 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade with two-foot separation from footing, using 6AWG insulated grounding conductor.
      b. Cable troughs alongside track: Bond and ground metal cable troughs to 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade, at approximate 50-foot intervals and at each end with two-foot separation from reinforced or buried metallic structures, using 4AWG insulated grounding conductor. At expansion and contraction joints, install 4AWG insulated grounding conductor for electrical continuity.
      c. Metallic railings and fences alongside track: Bond and ground railings and posts for galvanized steel fence to 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade, at approximate 50-foot intervals

and at each end, with two-foot separation from railing and fence-post footing and other reinforced structure, using 4AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4 AWG insulated grounding conductor. In addition to the above requirements for grounding galvanized steel fences, provide the following for grounding PVC-coated steel fences:

1) Bond and ground each fence post to bottom tension wire using 6AWG bare grounding conductor, O-Z Type CG, Burndy Type GAR or equal connector at fence post, and Burndy Type KS or equal tap connector at tension wire.

2) At connections of grounding conductors to posts and tension wires, remove vinyl coating at contact surfaces before making connections and apply vinyl coating over finished connections to match original coating.

d. Railing, cable trough and metallic-deck structure at aerial track:

1) In each abutment and pier, install 4/0 AWG insulated grounding conductor with one end connected to pile or one-inch diameter by 10-foot long ground rod, buried with top two feet below grade, with two-foot separation from concrete structure and three-foot pigtail on the top of pier or abutment for bonding and grounding of deck structure.

2) Bond and ground deck structure, cable trough and hand railing to 4/0 AWG insulated grounding conductor installed at each abutment and pier using 4AWG insulated grounding conductor. For providing electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4AWG insulated grounding conductor.

5. In underground locations, bond and ground hand railing and metallic safety walk grating at each end and at approximate 50-foot intervals to nearest ground bus or sub-bus, using 6AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 6AWG insulated grounding conductor.

6. Bus passenger and supervisor shelters equipped with light fixtures: Provide multiple ground paths as follows:

a. Bond and ground two separate frame columns of each single or double bus passenger shelter or supervisor shelter to two separate ground rods using 6AWG insulated grounding conductor. Drive 5/8-inch diameter by 10-foot long ground rod with top of rod six inches below finished grade.

b. Bond and ground each shelter to equipment grounding conductor in branch circuit.

7. Passenger shelter equipped with illuminated diorama and receptacle at station platform: Provide multiple ground paths as follows:

a. Bond and ground two separate frame columns of each shelter to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-foot long ground rod driven so that the top of rod is three inches above finished floor of under platform space using 6AWG insulated grounding conductor unless otherwise shown.

b. Bond and ground each shelter to equipment grounding conductor in branch circuit.

8. Illuminated diorama, station pylon equipped with light fixtures, map case and telephone enclosure: Provide multiple ground paths as follows:

a. Bond and ground illuminated diorama frame, column of station pylon equipped with light fixtures, map case and telephone enclosure to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-foot long ground rod driven so that the top of rod is three inches above finished floor of under platform space using 6AWG insulated grounding conductor unless otherwise shown.

b. Bond and ground frame of each illuminated diorama, pylon equipped with light fixture, map case and telephone enclosure to equipment grounding conductor in branch circuit.

9. Station entrance pylon (Type B): Provide multiple ground paths as follows:
   a. Bond and ground the pylon frame using 6AWG insulated grounding conductor to 5/8-inch diameter by 10-foot long ground rod driven so that top of rod is six inches below finished grade.
   b. Bond and ground the pylon frame to equipment grounding conductor in branch circuit.
10. Handhole, manhole and junction box metallic body, cover frame and cover: Provide a minimum of two ground paths as follows:
   a. Bond and ground handhole, manhole and junction box metallic cover frame and metallic body to 5/8-inch diameter by 10-foot long ground rod driven with top of rod three inches above bottom of manhole, handhole and junction box using 6AWG insulated grounding conductor.
   b. Provide a minimum of 6AWG insulated grounding conductor and a bronze or brass chain with 210-pound breaking strength in a ½-inch or 5/8-inch rubber hose to bond metallic cover to metallic cover frame. Length of cable, chain and hose as required to allow removal of cover adjacent to and clear of handhole and/or manhole opening.
   c. When cable is spliced in handhole, manhole or junction box, bond metallic cover frame and body to equipment grounding conductor.
11. Exothermically weld or gas torch braze grounding and bonding connection to exposed metallic structure, metallic cable trough, galvanized steel fence, hand railing, metallic safety walk grating, map case and telephone enclosure, frame columns of shelter, pylon and diorama, and metallic cover, metallic cover frame and metallic body of handhole, manhole and junction box. Repair damaged galvanized coating in accordance with Section 02820. Repair finish of shelter, map case and telephone enclosure and diorama frame to match existing finish.

3.02 BONDING FOR STRAY CURRENT AND CATHODIC PROTECTION:

A. Reinforcing Steel in Tunnel, At-Grade and Aerial Sections:
   1. Bond reinforcing steel using 250 MCM, Class G, stranded bare conductor exothermically welded to steel straps as shown, in accordance with Section 03200.

B. Floating-Slab Expansion Joints:
   1. Bond floating-slab expansion joints, using 1/0 AWG, Class G, stranded bare conductor exothermic welded to longitudinal bar.

C. Fabricated Gray-Iron or Ductile-Iron Tunnel-Lining Segments:
   1. Bond gray-iron or ductile-iron segments as shown in accordance with Sections 02415 and 02416.

D. Fabricated Steel Tunnel-Lining Segments:
   1. Bond steel segments as shown in accordance with Sections 02415 and 02417.

E. Metallic Pipe:
   1. Bond across joint for the following pipe, pipe fittings and pipe appurtenances, except those welded or soldered joints, using 2AWG insulated conductor as shown and in accordance with Section 15205.
      a. Buried pipe, except soil pipe unless shown bonded.
      b. Pressure pipe.
      c. Pipe parallel to and within 20 feet of centerline of track.

2. Do not bond District of Columbia, Department of Public Works (DCDPW), buried piping systems

F. Permanent Metal Piles:
1. Interconnect permanent metal piles, except those used in ground grid, using 4/0 AWG insulated conductor exothermically welded to piles. At each end of line of bonded piles, connect 4/0 AWG insulated conductor and terminate it in box inside line structure. Identify conductor termination using non-metallic tags or plastic labels attached to conductor with slip-free plastic lacing or nylon bundling strap.

G. Drainage Cables in Tunnel, At-Grade and Aerial Sections:
1. Between bonded reinforcing steel and negative switchboard in traction-power substation, install stray-current discharge cable in accordance with the following requirements:
   a. Adjacent to each traction-power substation, install two 250 kcmil, Class G, stranded bare conductors, one end of each conductor welded to the reinforcing steel which has been bonded as specified herein, and the other end terminated in 12-inch by 18-inch by 4-inch junction box.
   b. From the junction box, install two 250 kcmil insulated cables in FRE conduit to dc negative switchboard area of the traction-power substation for future connection by others.

H. Separate reinforcing steel and other buried metallic structures, bonded for stray current and cathodic protection, from ground grid, grounding electrode, or exposed metallic structures grounded for personnel safety. Metallic contact or electrical bonding between two systems is prohibited.

3.03 FIELD QUALITY CONTROL:

A. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.

B. Ground resistance not to exceed the following:
1. Ground grid/bus in ac-switchboard rooms, chiller plants, and traction-power substations: Two ohms.
2. Ground grid/bus in fan shafts, drainage-pumping stations, electrical rooms, dispatcher rooms, Bell system rooms, mechanical rooms and dc tie-breaker stations: Five ohms.

C. To meet resistance requirements, install additional ground rods or use permanent metal piles as ground rods.

D. Isolate permanent metal piles used for grounding from those bonded for stray-current and cathodic protection.

E. Test metallic conduits and raceways, metallic enclosures for equipment, metallic cable troughs, fences, metallic hand railings, metallic safety walk gratings, metallic structures, metallic covers, cover frames and bodies of manholes, handholes and junction boxes, frames of shelters, pylons and dioramas, map case and telephone enclosures, and poles for mounting lighting fixtures for continuity to grounding system.

F. Test resistance of connection between ground bus in train-control rooms/communications rooms and ground bus in associated ac-switchboard rooms, traction-power substations or dc tie-breaker stations for resistance not to exceed one ohm.

G. Conduct tests in presence of Engineer.

H. Inspect and test exothermic welds as follows:

1. Inspect finished exothermic welds for visual characteristics that are consistent with a properly made connection in accordance with the manufacturer's instructions and recommendations. Remove welds that do not meet minimum visual requirements as acknowledged by the Engineer, and reweld after cleaning the area to be welded.
2. Test mechanical strength of exothermic weld by applying three sharp blows to the weld with a two-pound hammer using 15-inch strokes. Acceptable welds to sustain the blows without cracking the weld metal or the bond between the two connecting materials. Remove defective welds and reweld after cleaning the area to be welded.

END OF SECTION

SECTION 16120

WIRE, CABLE AND BUSWAYS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing wire, cable and busways.

B. Definitions:
   1. Cable: Cable having low smoke generating characteristics.

C. Requirements for single-conductor cable and for multiple-conductor cable as stated except as otherwise specified.

D. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Wire connection accessories: Section 16125.
   3. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar wire, cable and busways.

B. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. National Electrical Code (NEC).
   3. Insulated Cable Engineers Association (ICEA): S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
   4. IEEE: 1202-1991 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 383-1974 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
   5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
   6. American National Standards Institute (ANSI): *C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear; C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear; C37.20.3, Metal-Enclosed Interrupter Switchgear; Z55.1, Gray Finishes for Industrial Apparatus and Equipment*.
   7. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords.
   8. American Standards of Testing and Materials (ASTM): B3-95, Standard Specification for Soft or Annealed Copper Wire; B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; D471-98e1, Standard Test Method for Rubber Property-Effect of Liquids, E662-97, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
   9. ITS: Directory of ITS Listed Products

C. Source Quality Control:
   1. Cable and busways: Listed or labeled per UL or ITS directory.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Samples:
      a. Smoke-density test sample for jacket material: Specified sample will become property of the Authority.
   3. Certification:
      a. Certified flame-retardancy test reports (VW-1, IEEE 383, and IEEE 1202, Article 18) and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished. Include test reports with submittal of shop drawings.
      b. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials which are identical to those of the furnished cable. Include test reports with submittal of shop drawings.
      c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA Standards. Submit test reports prior to cable shipments.
      d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label per referenced UL or ITS directory, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.

B. Ship each unit securely packaged and labeled for safe handling and shipment.

C. Store products in a dry and secure facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Single-Conductor and Multiple-Conductor Cable:
   1. Type and size: As shown.
   2. Rated voltage: 600 volts.
   3. Conductors:
      a. ASTM B3 or B8 annealed copper.
      b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
      c. Size 8 AWG and larger: Class B stranded.
   4. Standards: Except as modified, wires and cable complying with the following standards:
      a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
      b. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
   5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable:
      a. Chlorosulfonated polyethylene or cross-linked polyolefin.

b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.
   1) Tensile strength, minimum pounds per square inch: 1,800.
   2) Elongation at rupture, minimum percent: 150.
   3) Aging requirement: After 168 hours in air oven test at 100C, plus-or-minus one degree C:
      a) Tensile strength, minimum percentage of unaged value: 100.
      b) Elongation at rupture, minimum percentage of unaged value: 80.
   4) Oil immersion: 18 hours at 121C, plus-or-minus one degree C, ASTM D471, Table 1, No. 2 oil:
      a) Tensile strength, minimum percentage of unaged value: 80.
      b) Elongation at rupture, minimum percentage of unaged value: 80.

c. Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket material free of PVC and PVC-based compounds.

6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:
   a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical wire (VW-1) flame test in accordance with UL1581 or ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Cable size for testing: 14AWG.
   b. Single-conductor cable , size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202 or IEEE 383. Cable size for testing: 1/0 AWG.
   c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing: 7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.
7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.
   a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.
   b. Prepare slab specimens for each material .100 inch, plus-or-minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.
      1) Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.
   c. Test values for chlorosulfonated polyethylene not to exceed the following:
      1) Flaming mode:
         a) Uncorrected maximum specific optical density during first four minutes of test: 325.
         b) Uncorrected maximum specific optical density for entire 20-minute test: 400.
      2) Nonflaming mode:
         a) Uncorrected maximum specific optical density during first four minutes of test: 325.

b) Uncorrected maximum specific optical density for entire 20-minute test: 480.

d. Test values for cross-linked polyolefin not to exceed the following:

1) Flaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 150.

b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

2) Nonflaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 150.

b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

8. Applied voltage testing:

a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric-strength test, i.e., six-hour water-immersion test.

b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.

c. Test procedures:

1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.

B. Single-Conductor Cable:

1. Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL-Labeled as Type RHW-2.

2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

C. Multiple-Conductor Cable:

1. Individual conductors:

a. Number of conductors: As shown.

b. Construction: Complying with one of the following:

1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.

2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, without outer jacket.

3) Insulated with filled cross-linked polyethylene without jacket.

c. Phase and neutral conductors: Individually insulated.

d. Neutral conductors: Same size as phase conductors.

e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.

f. UL Listed as Type RHW-2 or XHHW-2.

2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.

3. Metallic sheath:

a. Provide one of the following:

1) Size 1 AWG and larger:

a) Interlocked aluminum-tape armor.

b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.

2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.

4. Multiple-conductor cable provided with overall non-metallic jacket as specified.
5. Cable UL-listed as follows:
   a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.
   b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
6. Color coding:
   a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
   b. Control cables: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

D. Fixture Wire: UL 62, with the following additional requirements:
1. Type: SF-2 silicone-rubber insulated or as necessary to suit temperature rating of lighting fixture, minimum 90C.
2. Conductor: Stranded copper conductor 16AWG or larger as shown.

E. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.

F. Busway (Busduct) and Fittings:
1. UL 857, NEMA BU1.
2. Totally enclosed, three-phase, four-wire feeder busway system, as shown, with necessary fittings, hanging devices, accessories and provision for flange bolting over circuit breaker.
3. Continuous current rating:
   a. Secondary tie duct for use in combined substation: Sized in accordance with ANSI C37.20.1, C37.20.2, C37.20.3, and NEC.
4. Voltage rating: 480/277 volts.
5. Busway system braced to withstand minimum short-circuit current of 75,000 amperes symmetrical, unless otherwise shown.
6. Maximum allowable temperature rise in busway at continuous full load above maximum ambient temperature of 40C: 55C.
7. Housing: Nonventilated, fabricated from galvanized sheet steel. Removable gasketed cover provided at transformer connection for maintenance and test. Hardware galvanized or cadmium-plated.
8. Joints:
   a. Single-bolt pressure joint designed for optimum electrical contact and mechanical strength.
   b. To permit safe testing of its tightness without de-energizing systems.
   c. To permit removal of duct sections without disturbing adjacent pieces.
   d. To permit making up joint from one side when busway is installed against wall or ceiling.
9. Busbars: Fabricated from 98-percent-conductivity copper and insulated over entire length except at joints and contact surface. Joints and contact surfaces tin-plated or silver-plated. Neutral bar same size as phase bar. Ground bar half size of phase bar.
10. Entire busway system polarized.
11. Expansion fittings provided where necessary.
12. Flexible connections, braided or laminated, provided for connecting bus conductor to transformer terminals.
13. Finish: Light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install type cable as specified.

B. Install single-conductor cable in conduit, underfloor duct or wireway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 16130. Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable and bus duct directly to channel inserts, or use expansion-bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry unit walls. Splice cable only when unavoidable.

C. Install motor feeders, service connections and extensions in accordance with reference codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit at motor conduit box.

D. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers and switchgear.

E. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692, and cable manufacturer.

F. To facilitate pulling cable, use listed per UL or ITS directory lubricant recommended by cable manufacturer.

G. Use direct-burial cable only for stray current and cathodic protection.

H. To install direct-burial cable, prepare trench of uniform width and free of sharp projections and rocks and place three-inch bed of sand. Do not pull cable directly into trench from stationary reel; unreel cable beside trench. Place cable on sand bed and backfill with three-inch deep sand cover. Fill remainder of trench with approved fill material and compact in accordance with Section 02320. Provide temporary supports in trench as necessary to prevent damage to insulation or jacket during installation.

I. In damp and dusty indoor locations, tunnel areas, manholes and outdoor locations, seal cable at conduit termination using duct-sealing compound.

J. Where shown or necessary, install cable-seal fitting specified in Section 16130 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16130.

3.02 IDENTIFICATION:

A. Identify cable terminations, feeders and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.

3.03 FIELD QUALITY CONTROL:

A. Furnish equipment required to perform tests. Prior to insulation and high-potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in presence of the Engineer.

B. Submit test procedure for approval and perform approved tests including, but not limited to, the following:

1. Single-conductor cable and multiple-conductor cable:
   a. Test continuity of cable conductors using ohmmeter.
   b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1,000-volt megger. Insulation resistance: 200,000 ohms minimum.
   c. When cable shows unsteady insulation resistance of less than 200,000 ohms, perform high-potential test at 80 percent of factory ac test voltage or as recommended by cable manufacturer.
2. Busway:
   a. Clean contact surfaces before making connections. For bolted connections, apply torque recommended by manufacturer.
   b. Test resistance of busway connections. Resistance not to exceed value recommended by manufacturer.
   c. Test insulation resistance to ground and between insulated busbars for minimum of one minute using 1,000-volt megger. Insulation resistance: One-megohm minimum. When busway shows insulation resistance of less than one-megohm minimum, perform high-potential test.

C. Submit certified test reports.

END OF SECTION

SECTION 16125

WIRE CONNECTION ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape and resin.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar wire connection accessories.

B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. UL: 486A,Wire Connectors and Soldering Lugs for Use With Copper Conductors.
4. American Standards of Testing and Materials (ASTM): D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials; D412-98a, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastic; D696-98, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer; D792-00, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement; D1000-99, Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications; D1518-85(1998)e1, Standard Test Method for Thermal Transmittance of Textile Materials; D5034-95, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test); D5035-95, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method); D2240-00, Standard Test Method for Rubber Property-Durometer Hardness; and G21-96, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
5. American National Standards Institute (ANSI): C119.1, Sealed Insulated Underground Connector System 600V
6. ITS: Directory of ITS Listed Products.

C. Source Quality Control:
1. Connectors, terminal lugs and fittings listed, per referenced UL or ITS directory.
2. Factory testing: Submit certified copies of test report for cable splice and tap-insulation/sealing kits as specified.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
2. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Connectors, Terminal Lugs and Fittings:
1. In accordance with UL 486A.
2. For 10AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
3. For 8AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.
4. For 250 Kcmil and larger conductor cable: Long-barrel, double-compression tin-plated copper connectors and terminal lugs with two-hole pad.
5. For multiple-conductor cable: Watertight aluminum fittings with stainless-steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC cable.

B. Bundling Straps:
1. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 40F to plus 185F.
2. For outdoor use: Ultraviolet-resistant.

C. Insulating Tape:
1. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degree F with the following minimum properties when tested in accordance with ASTM D1000-99:
   a. Thickness: 8.5 mils.
   b. Breaking strength: 20 pounds per inch width.
   c. Elongation: 200 percent.
   d. Dielectric breakdown: 10,000 volts.
   e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
2. Rubber tape: Silicone-rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:
   a. Thickness: 12 mils.
   b. Breaking strength: 13 pounds per inch width.
   c. Elongation: 525 percent.
   d. Dielectric breakdown: 13,000 volts.
   e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
3. Arcproof tape: Flexible, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:
   a. Thickness, ASTM D1000: 30 mils.
   b. Breaking strength, ASTM D5034-95 and D5035-95: 50 pounds per inch width.

c. Thermal conductivity, ASTM D1518-85: 0.0478 BTU per hour per square foot per degree F.
d. Electrical arc resistance: Withstand 200 amperes arc for 30 seconds.

4. Glass tape: Woven-glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:
a. Nominal width: 3/4 inch.
b. Thickness: Seven mils.
c. Breaking strength: 170 pounds per inch width.
d. Elongation: Five percent.
e. Dielectric breakdown: 2,500 volts.
f. Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.

D. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:
1. Dielectric strength, ASTM D149-97a: 400 volts per mil.
2. Volume resistance, ASTM D257-99: 2.8 x 10^{15} ohm per centimeter cube at 30C.
3. Water absorption, ASTM D570-98:
a. 0.193 percent in 24 hours at 23C.
b. 0.62 percent in 24 hours at 53C.
4. Tensile strength, ASTM D638-00: 8,000 psi.
5. Elongation, ASTM D638-00: 2.4 percent.
6. Coefficient of expansion, ASTM D696-98: 6.8 X 10-5 inch per inch per degree C.

E. Cable splice and tap-insulation/sealing kit: Suitable for use on 600-volt, 90C cables, material compatible with cable insulation and jacket, meeting the seal test requirements of ANSI C119.1.
1. Heat-shrinkable tubing or wraparound heat-shrinkable sleeve: approved per referenced UL or ITS directory, flame-retardant, corrosion-resistant thick-wall tubing with factory-applied sealant for field insulation on in-line splices and taps or wraparound-type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional requirements:
a. Material: Cross-linked polyolefin.
b. Shrink ratio: 3 to 1 minimum.
c. Physical properties:
1) Ultimate tensile strength: 2,350 psi, ASTM D412-98a.
2) Ultimate elongation: 350 percent, ASTM D412-98a.
3) Hardness, Shore D: 42, ASTM D2240-00.
4) Water absorption: 0.050 percent, ASTM D570-98, Method 6.1.
5) Specific gravity: 1.28, ASTM D792-00.
d. Electrical properties:
1) Dielectric strength: 450 volts per mil, ASTM D412-98a.
2) Volume resistivity: 1 x $10^{14\ ohm}$ cm, ASTM D257-99.
e. Thermal properties:
1) Continuous operating temp.: -55C to +135C.
2) Air oven aging (14 days at 175C):
a) Tensile strength: 2,680 psi.
b) Elongation: 375 percent.
3) Low temp. flexibility (4 hours at -55C): No cracking when flexed.
4) Heat shock (4 hours at 250C): No cracking, flowing or dripping.
f. Chemical properties:
1) Corrosivity: Non-corrosive.
2) Fungus resistance: Non-nutrient, ASTM G21-96.
3) Flammability: Self-extinguishing.

PART 3 - EXECUTION

3.01 SPLICES AND TERMINATIONS:

A. Make wire and cable splices in outlet, junction or pull boxes, in cable troughs or in equipment cabinets. Splices in conduit are prohibited.

B. Secure connectors or terminal lugs to conductor so as to engage all strands equally.

C. Do not rupture insulation nor expose bare conductors.

D. Install compression connectors and terminal lugs using tools and pressure recommended by manufacturer. Indent mark connectors and terminal lugs with number of die used for installation.

E. Apply anti-corrosion joint compound to connectors, terminal lugs and bolting pads before installation.

F. Wrap ½-lapped layer of arcproof tape, glass tape overall on cable splices installed in air tunnels, ducts and shafts.

G. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.

H. On cable splices, taps and terminations in manhole handhole and outdoor junction and pull boxes, cover connectors with electrical putty, wrapped with three layers of plastic tape or final layer of rubber tape and then install watertight encapsulation as follows and under the supervision of kit manufacturer's representative or using a factory-certified installation technician, proficient in field installation of heat-shrinkable sealing kits.
   1. Use heat-shrinkable tubing for encapsulation of new splices, taps and terminations.
   2. Use wraparound-type heat-shrinkable sleeve for encapsulation of existing splices, taps and terminations.

3.02 CATHODIC PROTECTION SPLICES AND TERMINATIONS:

A. For splices made in aboveground cable, use compression connectors covered with electrical putty, wrapped with three layers of plastic tape and final layer of rubber tape.

B. Install compression terminal lugs using tools and pressure recommended by manufacturer. Indent mark terminal lugs with number of die used for installation.

C. For splices made in direct-burial cable, use thermit weld sealed with cast epoxy-resin encapsulation.

3.03 INSPECTION:

A. Have splices in direct-burial cable for stray current and cathodic protection inspected by the Engineer before backfilling.

B. Have splices and taps in manholes, handholes and outdoor junction and pull boxes inspected by the Engineer or the manufacturer's representative, when available.

END OF SECTION

SECTION 16130

RACEWAYS, BOXES AND CABINETS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing conduit, raceways, cable trays, boxes and cabinets to form raceway and support system for power, communication and control cables.

B. Related Work Specified Elsewhere:
1. Underground electrical and communications distribution systems: Section 02585.
2. Concrete formwork: Section 03100.
3. Cast-in-place structural concrete: Section 03300.
4. Structural precast concrete: Section 03400.
5. Grounding and bonding: Section 16060.
6. Firestopping: Section 07841.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar raceways, boxes and cabinets.

B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum); VE 1, Metallic Cable Tray Systems; TC-2, Electrical Polyvinyl Cloride (PVC) Tubing and Conduit.
4. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc Coated; C80.5, Aluminum Rigid Conduit - (ARC); and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
5. UL: 5, Surface Metal Raceways and Fittings; 6, Rigid Metal Conduit; 50, Enclosures for Electrical Equipment; 94, Test for Flammability of Plastic Materials for Parts in Devices and Applicances; 360, Liquid Tight Flexible Steel Conduit; 514A, Metallic Outlet Boxes; 514B, Fittings for Conduit and Outlet Boxes; 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers; 651, Schedule 40 and 80 Rigid PVC Conduit; 884, Underfloor Raceways and Fittings; and 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
6. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.
7. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A123/A123M-00, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; A185-97, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled; A532/A532M-93a(1999)e1, Standard Specification for Abrasion-Resistant Cast Irons; A536-84(1999)e1, Standard Specification for Ductile Iron Castings; A615/A615M-00, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; A653/A653M-00, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; B138-96, Standard Specification for Manganese Bronze Rod, Bar and Shapes; B455-96, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes; B584-00, Standard Specification for Copper Alloy

Sand Castings for General Applications; B633-98, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; C109/C109M-99, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens); C173-94ae1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; C231-97e1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D495-99, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastics; D648-00a, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position; and D790-00, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

8. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges (SSHB).
9. ITS: Directory of ITS listed products.

C. The following items to be listed or labeled per referenced UL or ITS directory:
   1. Conduit and fittings.
   2. Surface raceways and fittings.
   3. Underfloor raceways and fittings.
   4. Boxes.
   5. Cabinets.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Conduit, Raceways, Cable Trays, Boxes, Cabinets and Fittings:
   1. Size: As shown, minimum conduit size 3/4 inch.
   2. Materials:
      a. Steel sheet: ASTM A507-00.
      b. Zinc-coated steel sheet: ASTM A653/A653M-00.
      c. Cast iron: ASTM A532/532M-93a(1999)e1.
      d. Ductile iron: ASTM A536-84(1999)e1.
      e. Malleable iron: ASTM A47/A47M-99.
      f. Bronze extrusion: ASTM B455-96, Alloy C38500.

g. Bronze casting: ASTM B584-00, Alloy C83600.
h. Rigid fiberglass reinforced epoxy: UL 1684.
i. Stainless steel: ASTM A276-00a, Type 304.

3. Zinc coating:
a. Hot-dip galvanizing: ASTM A123/A123M-00.
b. Electro galvanizing: ASTM B633-98.

B. Galvanized-Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.

C. Plastic Conduit and Fittings:
1. PVC, UL 651, NEMA TC-2, Schedule 40 and 80 heavy-wall, for use with 90C conductors.
2. Solvent cement: Manufacturer's standard.

D. Aluminum Rigid Conduit and Fittings:
1. ANSI C80.5 and UL 6.

E. Liquid-Tight Flexible Conduit and Fittings:
1. Applicable requirements of UL 360.
2. Flexible galvanized-steel core with extruded liquid-tight neoprene or PVC jacket overall.
3. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
4. Sizes 1-1/2 inch and above provided with separate grounding conductor.

F. Conduit Expansion Fittings and Expansion and Deflection Fittings:
1. Materials:
a. For galvanized-steel rigid conduit:
1) Expansion fittings: Steel or malleable iron, hot-dip galvanized.
2) Expansion/deflection fittings: Bronze or ductile iron end couplings, neoprene sleeve and stainless steel clamping bands.
b. For PVC conduit: Rigid metal expansion/deflection fitting with galvanized rigid steel to PVC conduit adapters at each end.
2. Conduit expansion fitting: Weatherproof.
3. Conduit expansion and deflection fitting: Watertight.
4. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.

G. Conduit Connector Fittings:
1. UL 514B, material and finish similar to that of conduit with which they are to be used.
2. For enclosures, cabinets, boxes and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.
3. For enclosure, cabinets, boxes and gutters with hub in outdoor, tunnel and underground locations, except electrical rooms: Threaded watertight hub fitting with gasket.
4. For enclosure having punched or formed knockout for conduit entry in outdoor and underground locations, except electrical rooms: Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknut.

H. Conduit and Cable-Seal Fittings:
1. Conduit seal:
a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
b. Size as shown or necessary.

c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of FRE or galvanized steel.
d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

2. Cable seal:
a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.
b. Size as necessary, drilled to accommodate cable.
c. Pressure discs of PVC-coated steel and sealing ring of neoprene.
d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.

3. Seal compound:
a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.
b. Pour-type for horizontal and gun-grade for vertical or overhead application.
c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40F to plus 150F without loss of watertight seal.
d. Pot life: 15 minutes.
e. Minimum ambient temperature for application: 35F.
f. Initial cure: 15 minutes.
g. Final cure: Seven days.
h. Hardness, Durometer A: 20-35.
i. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
j. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 70 psi without leakage.
k. Fox Industries, Type FX-571G or approved equal.

I. Conduit and Cable Supports:

1. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:
a. Type, style and size: As necessary.
b. Material and finish: Stainless steel, Type 304, or approved equal.
c. For separating conduit from masonry surface: Hot-dip galvanized malleable-iron spacer assembled with Style A strap.
d. For vertical run of metallic-sheath cable: Basket-weave cable support.
e. For fastening conduit or cable to channel inserts: Stainless steel, Type 304, or approved equal.

2. Multiple pipe hangers (trapeze-type): Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:
a. Material and finish: Stainless steel, Type 304, or approved equal.
b. Hanger rod: Not smaller than 3/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
c. Horizontal member: Channel, 1-1/2 inches square or 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.
d. Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500-psi maximum; stress in horizontal member 12,500-psi maximum.

3. Channel inserts:

a. Size and shape as shown, 12 gauge or heavier stainless steel, Type 304, or approved equal, with 7/8-inch wide slot.
b. For surface mounting: Channel inserts with 9/16-inch base slot, eight inches on center with minimum pullout-load rating of 1,000 pounds per linear foot.

4. Spot inserts: Rated 800 pounds with safety factor of five, fabricated from steel galvanized after fabrication, covered to prevent entrance of concrete during installation.

J. Surface Raceways and Fittings: UL 5, fabricated from galvanized steel.

K. Underfloor Raceways and Fittings:
1. UL 884.
2. Size: As shown.
3. Fabricated from steel 14 gauge or heavier steel sheet.
4. Finish: Corrosion-resistant coating listed per referenced UL or ITS directory.

L. Boxes and Cabinets:
1. Outlet boxes:
a. UL 514A, capable of accommodating conduit as shown.
b. Material and finish:
1) Steel, malleable iron, cast iron or ductile iron.
2) Hot-dip galvanized or electro galvanized after fabrication.
c. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.
d. For outdoor and underground locations, except electrical rooms:
1) Threaded-conduit entrance hub.
2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for enclosures having punched or formed knockouts for conduit entry.
e. For wall receptacles and switches, single or double devices: Outlet boxes 4-11/16 inch square by 1-1/2 inch deep.
f. For floor receptacles: Watertight cast-iron outlet boxes, four inches diameter, of suitable depth and complete with the following:
1) Adjustment screws for final leveling.
2) Bronze floor plate with flush-mounted screw plug, without exposed fastener, M32 finish.
3) Screw plug attached to outlet-box assembly by chain or other means, M32 finish.
4) Bronze floor plate flange, five inches in diameter, extending beyond box 1/2-inch above finished floor, M32 finish.
5) One special screw-plug removal tool with every 10 receptacles.
g. For recessed wall-mounted receptacles: Watertight cast-iron outlet box, three-inch diameter, of suitable depth and complete with the following:
1) Bronze faceplate with flush-mounted screw plug, without exposed fasteners, M32 finish.
2) Screw plug attached to outlet-box assembly by chain or other approved means, M32 finish.
3) Bronze faceplate flange, five inches in diameter, extending beyond box, M32 finish.
4) One special screw-plug removal tool with every 10 receptacles.
2. Junction and pull boxes:
a. Internal volume up to 100 cubic inches, metallic boxes: UL 514A, non-metallic boxes: UL514C; internal volume above 100 cubic inches, UL 50.
b. Flush-mounted or surface-mounted as shown.

c. Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.

d. Material and finish:

1) Metallic boxes:

a) Steel, malleable iron, cast iron or ductile iron.

b) Hot-dip galvanized or electro galvanized after fabrication.

c) Stainless steel in tunnel areas.

2) Non-metallic boxes:

a) Precast concrete: Compressive strength 3,500 psi; air entrainment six-percent minimum, ASTM C173-94ae1 or C231-97e1; Section 03300 and Section 03400 and in accordance with the following:

1) Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown.

2) Cover:

(a) Material same as for box. Use of metallic cover and cover frame prohibited.

(b) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.

(c) Non-protruding provisions provided for lifting.

3) Reinforcement:

(a) Sidewalk and landscape locations: Welded wire fabric, ASTM A185-97.

(b) Areas subject to vehicular traffic: Deformed steel bars, ASTM A615/A615M-00.

4) Loading:

(a) Sidewalk and landscape locations: AASHTO 's SSHB H15-44.

(b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.

(c) Hardware: Stainless steel.

(d) Size: As shown or next available larger size.

b) Composite material: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Method
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water Absorption (24 hours)	0.5 percent	ASTM D570

1) Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.

2) Cover:
   (a) Material same as for box.
   (b) Skid-resistant top surface with minimum 0.5 coefficient of friction.
   (c) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
   (d) Secured to box with bolts.
   (e) Non-protruding provisions provided for lifting.
3) Loading:
   (a) Sidewalk and landscape locations: AASHTO's SSHB H15-44.
   (b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.
4) Hardware: Stainless steel.
5) Size: As shown or next available larger size.

c) Molded fiberglass-reinforced polyester 1/8-inch thickness, minimum, and in accordance with the following requirements:

Physical Properties	Values	Method
Flexural strength	17,000 psi	ASTM D790
Deflection temperature	400F	ASTM D648
Water absorption (24 hours)	0.5 percent	ASTM D570
Tensile strength	6,500 psi	ASTM D638
Specific gravity	1.8	ASTM D794
Flammability	94-5V	UL 94
Dielectric strength	400 volts per mil	ASTM D149
Arc resistance	180 seconds	ASTM D495

1) Ultraviolet protection: Fiberglass material containing ultraviolet-inhibitor, or coated with polyurethane paint, 1.5 mils minimum dry-film thickness on both inside and outside surfaces.
2) Color: Fiberglass material, gray inside and outside.

d) Molded polyvinyl chloride 1/8-inch thickness, minimum.

e. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.

f. For outdoor and underground locations, except electrical rooms:
   1) Threaded conduit entrance hub.
   2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for boxes having punched or formed knockouts for conduit entry.

3. Cabinets:

a. UL 50, fabricated from galvanized steel.
b. Surface-mounted, unless otherwise shown.
c. Backplate of reinforced steel for mounting interior components and to ensure rigid support and accurate alignment.
d. Provision for cabinet grounding.
e. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
f. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and coated after fabrication with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

M. Cable Trays:
1. NEMA VE1, ventilated-steel ladder-type.
2. Dimensions: Three inches inside depth; nine inches rung spacing unless otherwise shown.
3. Maximum load rating: 50 pounds per linear foot with safety factor of 1.5 at 12-foot support span.
4. Bend radius:
a. For incoming service cable: As required by power company.
b. For all other cable: 24 inches or as necessary and approved.
5. Finish: Cable trays, fittings and accessories hot-dip galvanized or electro galvanized after fabrication.

N. Expansion Bolt Anchors: FS FF-S-325C Group II, stainless steel, Type 304, or approved equal.

O. Data-Transmission System (DTS) Cabinet:
1. Wall-mounted, single-door, NEMA 250 Type 12, with panel, Hoffman Engineering Company, as shown, or approved equal.
2. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground, without openings or knockouts, with threaded-conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure and door reinforced when size exceeds 30 inches square. Size as shown.
3. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to mate with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.
4. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.
5. Panel: Formed of 12-gauge steel.
6. Finish: Galvanized enclosure, door, panel and latch mechanism. Prepared for painting by manufacturer's standard method in accordance with the following:
a. Outside: Phosphatized, primed and finished with two coats of light-gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
b. Inside including panel: Two coats of white enamel or epoxy coating.
7. Breather drain: One 1/2-inch diameter, Crouse-Hinds Catalog No. ECD11, or approved equal.
8. Grounding stud: Manganese bronze, ASTM B138-96, Alloy No. 675 hard, 3/8-inch high; Evedur GSI, American Brass Company or approved equal.
9. Terminations: Assembly rail and modular terminals, Weidmuller Terminations, Incorporated or approved equal.
a. Terminal: Modular test terminal, Melamine plastic, screw-clamp connections, with socket screws; Type SAKC4, Catalog No. 3406.2 or approved equal, with the following additional requirements:
1) Amperes: 25.

2) Volts: 300.
3) Wire-gauge range: 22AWG to 12AWG.
4) Thickness: 0.256 inch.
5) Listed per referenced UL or ITS directory.
6) Standard accessories; compatible with terminal, with the following additional requirements:
a) End section: Type AP, No. 1179.2 or approved equal.
b) End bracket: Type EWK1, No. 2061.6 or approved equal.
c) Test plug: Type PS, No. 1804.0 or approved equal.
d) Cross-connection combination: QB25, No. 91455.D or approved equal.
e) Disconnect plug for SAKC4 terminal: Type TST, No. 3399.0 or approved equal.

b. Assembly rail: Type TS32 steel standard section compatible with terminals, with fixing slots, Catalog No. 1228.0 and standard rail-mounting screws or approved equal.

c. Marking tags: Dekafix 6.5-FS or approved equal, consecutive vertical, Number 4682.6 or Number 5766.6 as approved. Consecutive numbering conforming to that of DTS box.

d. Group marking carrier with paper marking strip and transparent cover.
1) Type SCHT5, Catalog No. 2924.6 or approved equal.
2) Type ESO5, Catalog No. 2937.0 or approved equal.
3) SST5, Catalog No. 2940.0 or approved equal.

P. Fiberglass Conduit and Fittings:

1. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
2. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.
3. IPS based conduit with nominal wall thickness of 0.09 inches for five-inch nominal conduit size.
4. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
5. Conduit sections formed with integral bell and spigot type couplings. Rubber sealing gasket at bell end is prohibited.
6. Conduits, elbows and fittings provided with protection from exposure to sunlight by pigmentation uniformly dispersed through resin material.
7. Adhesive as recommended by conduit manufacturer.
8. Conduits, elbows and fittings are specified for use throughout a temperature range of -40°F to 230°F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.
9. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 347 for Rigid Nonmetallic Conduit and its use.
10. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, mark clearly legible and durable every 10 feet or as recommended by the manufacturer.
a. "Reinforced Thermosetting Resin Conduit", "RTRC"; "Fiberglass Reinforced Epoxy Conduit", "FREC"; or equivalent, as applicable.
b. Normal Size: (IPS)
c. Manufacturer's name and trademark.
d. Temperature range for conduit application.
e. "Above Ground", "AG", "Below Ground", "BG", or equivalent wording, as applicable.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. General:
1. Use size, type, general routing, location of conduit, raceways, boxes and cabinets as shown and specified.
2. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.
3. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, nonabsorptive tape or coating to prevent corrosion.
4. Make metallic conduit, raceways, ducts and cable trays, electrically and mechanically continuous and ground them in accordance with Section 16060.
5. Install FRE conduit where conduit runs are embedded in concrete and where conduit is shown as direct-burial.

B. Conduit:
1. Run exposed conduit parallel to building lines.
2. Install exposed conduit to avoid interference with other work.
3. Traction-power substations, tie-breaker stations, ac-switchboard, electrical, train-control, communication and mechanical rooms: Where shown or where necessary to prevent seepage of subsoil or water into such areas, seal where conduits in contact with concrete and seal cable inside conduit using cable seal or sealing compound in accordance with the following requirements:
   a. Where shown and as necessary, install cable seal and conduit seal in accordance with the manufacturer's recommendations.
   b. Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:
      1) Before applying sealing compound, prime concrete, conduit and cable surface using primer recommended by manufacturer.
      2) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.
      3) Use FRE sleeve for conduit seal installed on traction-power, train-control and communication conduit.
   c. For 34.5 kv incoming-service cable with concentric neutral, install cable seal in traction-power substations, ac-switchboard rooms and 34.5 kv utility company manholes adjacent to WMATA facilities in accordance with the following requirements:
      1) Do all work in coordination with a utility company representative.
      2) Install O-Z CSBI cable seal at each end of the conduit for the service entrance cables (one at the last utility company manhole and one at the WMATA facility entrance). Use torque recommended by manufacturer for this type of cable seal, do not over-torque.
   d. For 13.8 kv incoming-service cable, install cable seal in traction-power substation, ac-switchboard rooms and utility company manholes adjacent to WMATA facilities. Coordinate the work with utility company representative.
   e. In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.
   f. All conduits free of water before conduit seals are installed.
4. Apply lead-free conductive anti-seize compound to threaded-conduit joints.

5. In outdoor and underground locations, except electrical rooms, use threaded-conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting with gasket, nylon-insulated throat and sealing locknuts for attachment of conduit to enclosure having punched or formed knockout.
6. In aboveground indoor locations and electrical rooms, use locknut and nylon-insulated bushing to attach conduit to enclosure.
7. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.
8. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.
9. Bends:
   a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
   b. Install bends in buried conduit in accordance with the following:

Size of Conduit (in inches)	Minimum Radius of Factory-Bend (in inches)	Minimum Radius of Field-Bend (in inches)
3	18	24
4	24	30
5	48	48
6	48	48

   c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.
   d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
10. Support conduit during construction to prevent distortion and to ensure independent support.
11. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.
12. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.
13. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.
14. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.
15. Support conduit above suspended ceiling using applicable specified methods.
16. Install conduit so as to drain moisture to nearest outlet or pull box.
17. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.
18. Do not use wire for support of conduit and cable.
19. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown. Install expansion/deflection fittings where embedded conduits cross structural expansion joints. Where embedded conduits cross a structural contraction joint, paint the external surface of conduit with linseed oil or other compatible bond breaker for two feet on each side of contraction joint.
20. Buried FRE conduit: Install in accordance with the following requirements in addition to those specified elsewhere:
   a. Arrange conduit to cross each expansion joint at right angle to joint.
   b. Prevent concrete and other materials from obstructing the conduit. Pack outlets, pull boxes and junction boxes and cap conduit ends prior to pouring concrete.
   c. Use Tight Lock Joint method to join conduit sections for providing water tightness and pull out strength.

d. Provide compatible conduit supports and spacers to maintain position of conduit during placement of concrete.
e. Install buried non-metallic conduit for cable over 600 volts in accordance with reference code.
f. Waterproof conduit connections.
g. Rod and swab conduit after installation so as to remove water, cement and other foreign matter; cap conduit ends. If obstructions cannot be removed or if condition exists which may result in damage to cable, replace conduit.
h. Leave approved nylon or polyester pull-line in each conduit.

21. Use metallic conduit or above ground FRE conduit in exposed locations.
22. Conduit installed in outdoor location: Waterproof conduit connection.
23. Use IPS FRE conduit for all concrete-encased applications except as follows:
    a. Use FRE conduit with minimum wall thickness of 0.95 inch for train control conduit direct buried without concrete encasement where shown.
    b. Install conduits encased in concrete ductbanks, associated manholes and handholes outside the structural work in accordance with Section 02585.

C. Channel Inserts and Spot Inserts:
1. Surface-mount channel inserts as shown.

D. Surface Raceways:
1. Install as shown.

E. Underfloor Raceways:
1. Install underfloor raceways as specified in Section 03100. Align and level raceways accurately. Hold raceways in place during placing of concrete.

F. Outlet, Junction and Pull Boxes:
1. Mount outlet boxes as shown.
2. Arrange front of box or attached plaster cover flush with finished wall or ceiling.
3. Keep number of knock-outs to minimum.
4. Clean boxes thoroughly after installation and correct damage to boxes and to finish.
5. Install covers on boxes mounted on walls and ceilings.
6. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.
7. Fasten floor boxes securely in place.
8. Install junction and pull boxes so that covers are readily accessible.
9. Do not install boxes above suspended ceilings except where ceilings are removable or definite provision is made for access to boxes.
10. Use stainless steel (Type 304) mounting channels, retaining straps and fasteners, pipe hangers for conduits and cables; expansion bolt anchors, junction boxes, outlet boxes, cover plates for receptacles, enclosures for load centers in tunnel environment which includes vent and fan shafts and underplatform areas.
11. Use non-metallic boxes as follows:
    a. Buried with cover flush-mounted with finish grade: Precast concrete or composite material junction and pull boxes within AASHTO load designations as specified.
    b. For indoor and outdoor locations not subject to pedestrian or vehicular traffic: Molded fiberglass-reinforced polyester junction and pull boxes.
    c. For outdoor locations but not for burial: Molded polyvinyl chloride junction and pull boxes.

G. Cabinets:
1. Fasten cabinet securely using expansion bolts, toggle bolts or mounting ears.
2. Touch-up damaged painted finish.

H. Cable Trays:
   1. Install cable trays neatly, adequately supported and as shown.
   2. For incoming-service cable from power company, install cable tray as approved by the power company.

I. Use expansion-bolt anchors to secure equipment to concrete surfaces.

J. Attachments to Prestressed-Concrete Girders:
   1. Attach pipes, conduits, boxes or similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except for track fasteners and appurtenances as shown.

K. DTS Cabinet and Terminals:
   1. Install as shown.

L. Car Wash Areas:
   1. Use PVC-coated galvanized steel conduit.

3.02 FILLING OF OPENINGS:

A. Where conduit and raceway pass through fire-rated walls, ceilings or floors, provide seals to prevent passage of fire and fumes and to maintain integrity of fire-rated structure in accordance with Section 07481.

B. Where openings are provided for passage of conduit and raceways in walls, ceilings or floors, use fire-resistant fibrous-glass safing or similar material to seal unused openings to prevent passage of fire and fumes in accordance with Section 07841.

C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.03 IDENTIFICATION:

A. At end of each run, use stainless steel or aluminum tags, minimum 1-1/2 inch diameter, with stamped markings, minimum 1/4-inch high lettering, and tag holders attached to conduit using a stainless steel band with worm screw clamping device to establish identification of conduits and raceways in accordance with designations shown. Where conduits are terminated flush with concrete structure, install three-ply laminated phenolic plate, engraved through black face to white core and attached adjacent to conduits' entrance by means of non-metallic screws. Engrave conduits' designations within circles arranged in pattern similar to that of conduits.

B. Identify by red painted color code and by marking EMERGENCY SYSTEM on all boxes and enclosures for emergency circuits to identify them as part of an emergency system in accordance with the NEC.

3.04 FIELD QUALITY CONTROL:

A. Arrange with the Engineer for inspection and approval of embedded conduit and boxes prior to concrete placement.

B. Arrange with the Engineer for inspection by electrical utility company representative of incoming-service conduit prior to placing concrete.

C. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of Engineer.

D. Test not less than 0.5 percent of total installed channel inserts and spot inserts as directed for compliance with specified pullout-load rating. Replace and retest inserts which fail. Conduct tests in presence of Engineer.

E. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

END OF SECTION

SECTION 16145

WIRING AND CONTROL DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing switches, cover plates, limit switches, occupancy sensors, receptacles, plugs, magnetic contactors, automatic transfer switches, photoelectric controls and time switches.

B. Related Work Specified Elsewhere:
1. Ornamental metal: Section 05700.
2. Wire connection accessories: Section 16125.
3. Grounding and bonding: Section 16060.
4. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. National Electrical Manufacturers Association (NEMA):WD1, General Color Requirements for Wiring Devices; KS1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum); ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC; ICS 12, Profiles of Networked Industrial Devices--Part 1: General Rules; NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. American National Standards Institute (ANSI): Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
5. UL: 98, Enclosed and Dead-Front Switches; 198D, Class K Fuses; 198E, Class R Fuses; 508, Industrial Control Equipment; 773, Plug-In Locking-Type Photocontrols for Use With Area Lighting; 1008, Transfer Switch Equipment.
6. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; and A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
7. ITS: Directory of ITS Listed Products

B. Source Quality Control:
1. Following items listed per referenced UL or ITS directory:
   a. Snap switches.
   b. Disconnect switches.
   c. Receptacles and plugs.
   d. Automatic transfer switch.
   e. Lighting contactor.
   f. Photoelectric control.
   g. Time switch.
   h. Occupancy sensor.

C. Qualifications: Select a manufacturer who is regularly engaged in the production of automatic transfer switches.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings.
2. Certification:
   a. Certified test reports of factory tests performed on each automatic transfer-switch unit in accordance with reference standards.
   b. Furnish certificate from manufacturer verifying that automatic transfer switches conform to specified requirements. Include certificate with submittal of shop drawings.
3. Documentation for Automatic Transfer Switch:
   a. Submit field test plan within 60 days after award with accompanying documentation in the form of test data recording sheets and list of proposed test equipment for approval prior to testing.
   b. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing.
4. Operation and Maintenance Manuals for Automatic Transfer Switch.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Snap Switches:
1. NEMA WD1, specification grade.
2. Rating:
   a. Twenty amperes at 120-277 volts ac.
   b. Horsepower-rated when used as disconnecting device for motor circuit.
3. Body and base: Fully enclosed, brown, fire-resistant, non-absorptive thermosetting urea or nylon.
4. Contacts: Silver alloy.
5. Mounting yoke: Corrosion-resistant metal with plaster ears.
6. Poles: Single-pole, double-pole, three-way or four-way as shown.

B. Disconnect (Safety) Switches:
1. UL 98, NEMA KS1, heavy-duty, fusible or non-fusible as shown.
2. Voltage rating: 240 volts ac, 480 volts ac or 250 volts dc as shown and as necessary.
3. Number of poles and current rating: As shown and as necessary.
4. Fuses:
   a. UL 198D.
   b. For fused disconnect switch associated with motor load: UL Class RK5 with time delay or as shown.
   c. For fused disconnect switch associated with other loads: UL Class RK1 or as shown.
   d. Current rating: As shown.
5. Enclosure: (NEMA 250)

a. Type:
   1) For aboveground indoor locations and electrical rooms: Type 1.
   2) For tunnel and underground locations, except electrical rooms: Type 4.
   3) For outdoor locations: Type 3R.

b. Materials:
   1) Steel sheet: ASTM A507-00.
   2) Malleable iron: ASTM A47/A47M-99.

c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

6. Quick-make/quick-break switching mechanism with operating handle external to enclosure with positions labeled ON/OFF and capable of being padlocked in OFF position, defeatable interlock to prevent opening of enclosure door when switch is closed.

C. Receptacles and Plugs:

1. NEMA WD1, specification grade.
2. Rating: 20 amperes at 125 or 250 volts as shown.
3. Base and body: Brown, fire-resistant, non-absorptive thermosetting urea or nylon.
4. Receptacles:
   a. Outlet: Single or duplex as shown.
   b. Mounting yoke: Corrosion-resistant metal with plaster ears.
   c. Configuration:

Rating	NEMA Configuration
Two-pole, three-wire, 20 amps, 125 volts	5-20 R
Two-pole, three-wire, 20 amps, 250 volts	6-20 R

   d. For use in restroom; water service room; locker room; wash rooms; elevator machine room, pit and hoistway; and outdoor locations: Equipped with solid-state ground-fault circuit interrupter with five-milliampere trip level.

5. Plugs:
   a. Configuration and design: As follows unless otherwise shown:

Rating		NEMA Configuration
Two-pole, three-wire, 20 amps, 125 volts	Urea or neoprene with cord grip	5-20 P
Two-pole, three-wire, 20 amps, 250 volts	Armored cap with cord grip	6-20 P

D. Cover Plates:

1. Wall plates:
   a. NEMA WD1, suitable for specified receptacles and switches, size suitable for recess-mounted or surface-mounted associated outlet box, stainless steel, ASTM A276-00a, Type 304, or approved equal.

b. For use in indoor public areas: Bronze, with M32 medium satin finish as specified in Section 05700.
c. For above ground indoor service areas and electrical rooms: Steel, stainless steel or aluminum plate, as standard with the manufacturer.
d. For receptacles in outdoor and underground locations, except electrical rooms: Stainless steel, ASTM A276-00a, Type 304, wall plate with gasketed spring-loaded hinged cover.

2. Floor plates: Section 16130.

E. Automatic transfer switch: UL-1008, electromechanical, in surface-mounted enclosure as shown, with the following additional requirements:

1. Operating and electrical characteristics:
   a. Capable of transferring load automatically from normal source to alternate source when the voltage drops to 85 percent of rated voltage on any phase for set time. Operating point adjustable over range of 80 to 90 percent of rated voltage and time-delay adjustable over range from zero to five minutes in increments of at least eight steps.
   b. Capable of transferring load automatically from alternate source to normal source when normal source returns to 90 percent of rated voltage for set time. Operating point adjustable over range of 85 to 100 percent of rated voltage and time-delay adjustable over range from zero to five minutes in increments of at least eight steps.
   c. Capable of transferring load automatically from normal source to alternate source when normal source failure is simulated by integral test switch.
   d. Rating:
      1) Number of poles: Three or four as shown.
      2) Voltage rating: 480-volt, three-phase, three-wire or 480Y/277-volt, three-phase, four-wire, 60 Hertz system as shown.
      3) Current rating: As shown and rated 100 percent.
      4) Transfer time: Ten cycles maximum on 60-Hertz base after initiation signal.
      5) Short-circuit current rating, rms symmetrical amperes: 14,000; 22,000; 25,000; 30,000; 35,000; or 50,000 as required and shown.
      6) Capacity to close into available short-circuit current or let-through current of fuses without functional degrading.
   e. Solid-state control panel for sensing and control logic with accuracy of plus-or-minus two percent on voltage and frequency settings over a temperature range of minus 20 degrees to plus 70 degrees.
2. Design and construction features:
   a. Mechanically held, electrically operated, double-throw switch.
   b. Electrical and mechanical interlock to prevent maintained neutral position.
   c. Designed to break-before-make on transfer and retransfer.
   d. Equipped with renewable silver-alloy contact.
   e. Neutral bus or terminal provided on 480Y/277-volt, three-phase, four-wire unit to allow interconnection of neutral conductors.
   f. Pilot lights on door to indicate switch position as follows:
      1) On normal source: Green light.
      2) On alternate source: Red light.
   g. Pilot lights on door to indicate:
      1) Normal source available: Green or white light.
      2) Alternate source available: Red or white light.
   h. Contacts opened by single solenoid, motor operator or stored energy mechanism.
   i. Handle provided to permit manual operation of automatic transfer switch for maintenance purposes.
   j. Power conductors made of silver-plated copper bus.

k. Equipment ground lug provided.

3. Enclosure:
   a. Type:
      1) For aboveground indoor locations and electrical rooms: NEMA Type1.
      2) For tunnel and underground locations, except electrical rooms: NEMA Type 12.
   b. Door: Hinged with handle and latch.
   c. Material: Steel.
   d. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and finished with gray enamel, ANSI Z55.1, Color No. 61; two mils minimum DFT.

F. Lighting Contactors:
1. NEMA ICS 2, UL 508, electrically held, equipped with silver-alloy contacts, designed to control incandescent, tungsten, halogen, fluorescent, high-intensity discharge lamp load.
2. Number of poles: As shown.
3. Continuous current rating: As shown.
4. Line and load voltage: 480-volt or 208-volt three-phase or 277-volt or 120-volt single-phase as shown.
5. Control coil rated 120 volts.
6. 480-volt or 277-volt to 120-volt control transformer fused on secondary and primary as required.
7. Control:
   a. Heavy-duty, three-position selector switch with positions labeled HAND/OFF/AUTO for lights controlled by photo-electric cell.
   b. ON-OFF push button for indoor lights.
8. Enclosure: NEMA 250, Type 1; fabricated from steel, cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

G. Photoelectric Control:
1. UL 773, designed to respond to natural daylight with 15-second inherent delay to prevent functioning due to sudden bright light such as vehicle lights or lightning and to operate in ambient temperature from minus 50C to plus 60C.
2. Adjust to turn lights ON at two plus-or-minus one foot-candles, unless otherwise specified. ON to OFF ratio: One to three.
3. Rating: 1,800VA at 120 volts or 277 volts, 60 Hertz, as shown.
4. Contacts:
   a. For control of outdoor lights: SPST, NC contact.
   b. For control of tunnel lights at portals: SPST, NO contact
5. Cells: Hermetically sealed.
6. Enclosure: Weatherproof and tamper proof aluminum or non-metallic enclosure equipped with locking receptacles when mounted on fixture or designed for mounting on outlet box as shown and as necessary.
7. At tunnel portal, set photoelectric control to turn on selected lights at dawn and turn off lights at dusk, as shown.

H. Limit Switches:
1. NEMA ICS 2, industrial-control.
2. Suitable for mounting in folding-gate cabinet. Switch contacts closed when cabinet door is fully closed and latched. Switch contacts opened when respective cabinet door is not fully closed.
3. Voltage rating: 120 volts ac.
4. Current rating: 10-amperes continuous.

5. Enclosure: NEMA 250, Type 13.
6. Actuator: Lever-operated and adjustable, with spring return.
7. Mounting: Plug-in type with receptacle tapped for conduit size as shown.
8. Contacts: Single-pole double-throw; one NO, one NC; snap action.

I. Time Switch:
1. Seven-day and 24-hour calibration for each day time switch, listed per referenced UL or ITS directory, heavy-duty type suitable for controlling type of lighting fixtures shown.
2. Type: As shown, with contacts capable of switching continuous load of 20 or 40 amperes per pole at 277 volts as necessary.
3. Seven-day, 24-hour dial with day and night zones and 24-hour calibration for each hour clearly marked.
4. Providing up to four automatic ON/OFF operations each day.
5. Removable ON/OFF trippers designed for minimum ON period of one hour and minimum two-hour period between one OFF operation and next ON operation.
6. Provision for manual ON and OFF operation of switch by hand without disturbing weekly preset schedule.
7. Provision for omitting operation of switch on selected days.
8. Spring-driven reserve power suitable for operation of switch for 16 hours minimum after failure of power. On restoration of power, switch transfers to synchronous motor drive and automatically rewinds spring.
9. Terminals designed to accommodate up to 8AWG conductor cable.
10. Operation at 480/277Y or 208Y/120 volts, 60 Hertz as shown and within temperature range of zero degree F to plus 140F.
11. Enclosure:
    a. NEMA 250, Type 1, steel, surface-mounted.
    b. Hinged flush front door with catches and spring-loaded door pull.
    c. Finish: Metallic surfaces cleaned and degreased, primed with zinc primer and finished with one coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

J. Occupancy Sensor:
1. UL 508, passive infra-red motion detector designed for wall mounting over single-gang outlet box, minimum radio frequency interference and use with incandescent and fluorescent lighting fixtures and electronic ballasts.
2. Voltage rating: 120-277 volts ac.
3. Switching capacity:
    a. 120-volt operation: 800 watts minimum.
    b. 277-volt operation: 1,500 watts minimum.
4. Coverage area: 1,000 square feet.
5. Detection zone:
    a. Horizontal: 180 degrees.
    b. Vertical: 5 degrees.
6. Ambient light sensing: Photocell for preventing operation of lights at ambient light levels above an adjustable setting.
7. Adjustments: Adjustable settings for time delay, sensitivity and light level concealed by tamper proof cover. Time delay adjustable from 10 seconds to 15 minutes after motion stops.
8. Operating mode: OFF/AUTO.
9. Detection indicator: LED.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install switches, limit switches, occupancy sensors, receptacles, automatic transfer switches, lighting contactor, photoelectric controls and time switches as shown and in accordance with referenced codes and standards in Article 1.2, and manufacturer's instructions.

B. Install cover plate on switch and receptacle.

C. Install cover plate with gasketed spring-loaded cover, on each receptacle in outdoor and underground locations except electrical rooms.

D. Ground disconnect switch, time switches, automatic transfer switches, receptacles, snap switches, photoelectric controls and lighting-contactor enclosures in accordance with Section 16060.

E. Make power cable connections to snap switches, plugs, time switches, occupancy sensors, photoelectric controls, receptacles, automatic transfer switches and lighting contactors by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

F. Make power cable connections to snap switches and receptacles using their side screw wiring connection terminals.

G. Apply matching touch-up paint as necessary.

3.02 FIELD QUALITY CONTROL:

A. Furnish necessary test equipment and perform the following in the presence of the Engineer, in accordance with approved procedures:

1. Test time switches, receptacles and contactors for connection in accordance with wiring diagram.
2. Test equipment enclosure for continuity to grounding system.
3. Check tightness of cable connections of snap switches, receptacles, time switches, occupancy sensors, disconnect switches, automatic transfer switches, lighting contactors, photoelectric controls and limit switches.
4. Test operations of circuits and controls of switches, occupancy sensors, receptacles and contactors.
5. Automatic transfer switches:
   a. Test switches for connection in accordance with wiring diagrams.
   b. Calibrate and set voltage-sensing device for each source and time delay for transfer and retransfer as follows and as approved:
      1) Automatic transfer switches for fan shafts and drainage pumping stations: Time delay setting for transfer equal to total of 30 seconds for each connected motor or additional time as required.
      2) Time delay setting for retransfer equal to or greater than time delay setting for transfer.
   c. Perform automatic transfer of load in accordance with the following requirements:
      1) With power available on both the normal and alternate sources, initiate automatic transfer from the normal source to the alternate source by opening the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source. Check that the switch position changes to the alternate source and remains connected to the alternate source.
      2) With power available on the alternate source and the switch connected to the alternate source, initiate automatic transfer to the normal source by closing the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source.

Check that the switch position changes to the normal source and remains connected to the normal source.

3) If testing indicates failure to comply with specified requirements, modify settings for the automatic transfer switch so that the specified requirements are met. Conduct additional tests witnessed by the Engineer to prove compliance with specified requirements.

B. Submit certified test reports for compliance with field quality control requirements.

END OF SECTION

SECTION 16225

MOTORS

PART 1 - GENERAL

1.01 DESCRIPTIONS:

A. This section specifies providing motors.

B. Related Work Specified Elsewhere:
   1. Grounding and bonding: Section 16060.
   2. Wire connection accessories: Section 16125.
   3. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of jurisdictional authorities.
   2. NEC.
   3. IEEE: 85, 112.
   4. NEMA: MG1.
   5. ANSI: Z55.1.
   6. ASTM: A582.
   7. OSHA: 1910.95.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Outline dimensions.
      b. Cross section showing internal construction and weight.
      c. Connection diagram.
   2. Certification.
   3. Operation and Maintenance Manuals.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship each motor securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motors in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Motors:
   1. NEMA MG1, squirrel-cage, induction-type, unless otherwise shown.
   2. Rating:
      a. Horsepower: As shown.
      b. Voltage and frequency:
         1) Motors, 1/2 HP and smaller: 115-volt, single-phase, 60 Hertz.

2) Above 1/2 HP: 460-volt, three-phase, 60 Hertz, unless otherwise specified or shown.
3) For motors in air-conditioning units:
a) For units up to and including 10,000 BTUH: 115-volt, single-phase, 60 Hertz.
b) For units from over 10,000 BTUH up to and including 36,000 BTUH: 208-volt, single-phase, 60 Hertz.
c) For units over 36,000 BTUH: 460-volt, three-phase, 60 Hertz.

c. RPM: As shown.
d. Time rating: Continuous, unless otherwise shown.
e. Nominal full-load efficiency: Premium Efficency when tested in accordance with NEMA MG1 and IEEE 112.

3. Design:
a. Single-phase motors: Design N, suitable for full-voltage across-the-line starting.
b. Three-phase motors: Design B, unless otherwise shown, with the following additional requirements:
1) Up to and including 50-HP motors: Suitable for full-voltage across-the-line starting.
2) Above 50-HP motors: Suitable for reduced-voltage starting.

4. Service factor:
a. Motors, one HP and smaller: In accordance with NEMA MG1.
b. Above one-HP up to and including 200-HP motors: 1.15.
c. Above 200-HP motors: 1.00.

5. Insulation: Class and allowable temperature rise above average ambient temperature of 30C and maximum ambient temperature of 40C as follows:
a. Integral-horsepower motors:
1) Dripproof motors: Class B insulation with Class B temperature rise.
2) Totally enclosed motors: Class F insulation with Class B temperature rise, unless otherwise shown or specified.
b. Fractional-horsepower motors: In accordance with NEMA MG1.

6. Noise level: NEMA MG1-12.49 but not to exceed requirements of OSHA 1910.95 when measured in accordance with IEEE 85.

7. Enclosure:
a. Dripproof, fully guarded; totally enclosed fan-cooled guarded; or totally enclosed air-over as specified.
b. Heavy-duty steel or cast-iron frame.
c. End bell:
1) Up to 10HP: With cast-iron or aluminum end bells.
2) 10HP and above: With cast-iron end bells.
d. Mounting: Foot-mounted on pad or adjustable pad, if necessary or as otherwise shown.
e. Provision for grounding.
f. Finish: Red-oxide zinc-chromate primer with finish coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
g. Totally enclosed air-over:
1) Variation to totally enclosed fan-cooled machines with air flow for cooling supplied by fan specified elsewhere.
2) Fan/motor application factory-engineered for air flow shown or specified.

8. Conduit box:
a. Diagonally split, suitably gasketed.
b. Type:
1) Up to 10HP: Steel, cast iron or aluminum with threaded or punched conduit holes.

2) 10HP and above: Cast iron with threaded conduit holes.

c. Size suitable to accommodate motor and line leads including taping.

d. Capable of rotation in each 90-degree position.

9. Bearings:

a. Unless otherwise specified, average life 15 years, but not less than three years at continuous operation, with double shields.

b. Integral-horsepower motors:

1) Five HP and smaller: Sealed ball bearings or roller bearings.

2) Above five HP: Ball bearings or roller bearings with grease fittings and pressure-relief fittings for in-service lubrication.

c. Fractional-horsepower motors:

1) 1/6 HP and larger: Sealed ball bearings.

2) Below 1/6 HP: Sealed ball bearings or sleeve.

10. Motors for hermetically sealed and semi-hermetically sealed compressors: NEMA MG1, 18.076 through 18.093.

11. Motors for close-coupled pumps: Stainless-steel shaft in accordance with ASTM A582, Type 303.

12. Provide nameplate on each motor in accordance with NEMA MG1-10.37.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install motors where shown and in accordance with the NEC.

B. Install conduit in accordance with Section 16130.

C. Connect power cable as shown and in accordance with Section 16125.

D. Ground motor enclosure in accordance with Section 16060.

3.02 FIELD QUALITY CONTROL:

A. Furnish necessary equipment and perform the following tests:

1. Check and test wiring connections in accordance with wiring diagram.
2. Test to ensure that insulation resistance of motor winding is 10 megohms minimum.
3. Test motor enclosure for continuity to grounding system.
4. Test motors for proper operation with their associated controls.

B. Submit certified test reports.

END OF SECTION

SECTION 16425

MOTOR STARTERS AND CONTROL CENTERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing motor starters and control centers.

B. Related Work Specified Elsewhere:
1. Grounding and bonding: Section 16060.
2. Circuit breakers, panelboards and load centers: Section 16440.
3. Motors: Section 16225.
4. Wire connection accessories: Section 16125.
5. Raceways, boxes and cabinets: Section 16130.
6. Unit substation: Section 16360.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of jurisdictional authorities.
2. NEC.
3. NEMA AB1, ICS-2, ICS-2.3, 250.
4. ANSI: Z55.1.
5. ASTM: A47, A653, B187.
6. UL: 845, Electrical Construction Materials Directory
7. ITS: Directory of ITS Listed Products.

B. The following items to be listed or labeled per referenced UL or ETL directory.
1. Motor starter.
2. Combination starters.
3. Motor circuit protectors.
4. Motor control centers.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Interconnection wiring diagrams.
2. Certification.
3. Operation and Maintenance Manuals.
4. Short-circuit calculations and coordination study in accordance with Section 16360.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motor starters and control centers in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Motor Starters:
   1. Interchangeability: Equipment of same type, size, rating, functional characteristics and make is to be interchangeable.
   2. NEMA ICS-2, ac general-purpose, Class A.
   3. Rating: Continuous-current rating suitable for associated motor as shown.
   4. Type:
      a. Up to and including ½ HP: Manual starter operable on 120-volt, single-phase, 60 Hertz supply unless otherwise shown.
      b. From above ½ HP up to and including 50 HP: Across-the-line magnetic starter operable on 480-volt, three-phase, 60 Hertz supply.
      c. Above 50 HP: Closed-transition autotransformer starter operable on 480-volt, three-phase, 60 Hertz supply.
   5. Provide ground-fault protection with five-ampere pick-up in each motor starter for fans in fan shafts and pumps in drainage-pumping stations.
   6. Enclosure:
      a. Type:
         1) For aboveground indoor locations and electrical rooms: NEMA 250, Type 1.
         2) For tunnel areas and underground locations except electrical rooms: NEMA 250, Type 12.
         3) For outdoor locations: NEMA 250, Type 3R.
      b. Materials:
         1) Zinc-coated steel sheet: ASTM A653, coating designation G90, minimum thickness 14 gauge.
         2) Malleable iron: ASTM A47.
      c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
   7. Nameplate:
      a. Nameplate provided on each motor starter and control center in accordance with NEMA ICS, showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable.
      b. Additional functional nameplates for each component as follows:
         1) Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless-steel rivets or screws.
         2) Lettering to be vertical gothic using a round or square cutter. V-shaped groove not acceptable.
         3) Each starter labeled with one-inch wide nameplate showing starter's designation and function in ½-inch high characters.

B. Manual Starters: Quick-make/quick-break toggle mechanism, manual-reset thermal-overload device, position indicator showing ON/OFF/TRIPPED positions, red indicating light showing closed position.

C. Across-The-Line Magnetic Starter:
   1. Reversing or nonreversing as shown.
   2. NEMA size: As shown, not smaller than NEMA 1.
   3. 480-volt primary to 120-volt secondary control transformer with fuse in the primary circuit
   4. Manual-reset overload relay, one per phase, with the following additional requirements:
      a. In starter for motors in fan shafts: Magnetic-type sensitive to current.
      b. In starters for motors in other locations: Thermal-type.
   5. Two NO contacts with provision for addition of two NO or NC contacts.
   6. Nonreversing-type: START/STOP pushbutton mounted on door.

7. Reversing-type: FORWARD/REVERSE/STOP pushbutton mounted on door.
8. HAND/OFF/AUTO selector switch provided when specified.

D. Autotransformer Starter:
1. Reversing or nonreversing closed-transition type as shown.
2. NEMA size: As shown.
3. Adjustable taps for 50, 65 and 80 percent of line voltage.
4. 480-volt primary to 120-volt secondary control transformer with fuse in primary circuit.
5. Manual-reset overload relay, one per phase.
   a. In starter for motors in fan shafts: Magnetic-type sensitive to current.
   b. In starters for motors in other locations: Thermal-type.
6. One pneumatic adjustable timing relay.
7. Two NO contacts with provision for addition of two NO or NC contacts.
8. Nonreversing-type: START/STOP pushbutton mounted on door.
9. Reversing-type: FORWARD/REVERSE/STOP pushbutton mounted on door.
10. HAND/OFF/AUTO selector switch provided when specified.

E. Motor Circuit Protectors (MCP):
1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism with adjustable magnetic trip for instantaneous short-circuit protection.
2. Rating:
   a. Number of poles: Three.
   b. Continuous-current rating: As shown, not less than full-load current of motor.
   c. Voltage: 480-volt, three-phase, 60 Hertz.
   d. Interrupting rating: As shown.
   e. Trip range: As necessary to provide maximum protection to associated motor.
3. Where shown or necessary, individually removable current limiter, internally mounted on load side of MCP, with the following additional requirements:
   a. Limiter current rating and time-current limiting characteristics coordinated with time-current characteristics of MCP to provide the following:
      1) Interruption by MCP under fault-current level up to interrupting capacity of MCP.
      2) Interruption by current limiter in conjunction with the MCP of fault-current level above interrupting capacity of MCP.
      3) Where necessary to protect associated motor starter. Limit fault-current below withstand capability of the starter.
      4) Where necessary to protect associated motor-circuit conductors. Limit fault-current below withstand capability of cable insulation.
   b. Current-limiter housing interlocked with MCP tripping mechanism so that breaker will trip upon removal of cover.
   c. Equipped with common trip mechanism for tripping all poles simultaneously on blowing of current limiter to prevent single phasing.
   d. Capable of interrupting minimum fault-current up to 100,000 rms symmetrical amperes at 480 volts ac.

F. Combination Starter:
1. NEMA ICS-2, rated 480 volts, three-phase, 60 Hertz.
2. Motor starter: Across-the-line magnetic or autotransformer starter as shown and specified.
3. One 480-volt, three-pole MCP.
4. Externally mounted operating handle with position indicator showing ON/OFF/TRIPPED condition of MCP. Operating handle interlocked for preventing

opening and closing of door when MCP is in ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.

G. Motor Control Centers:

1. NEMA ICS-2.3, Class 1, Type B, rated 480-volt, three-phase, 60 Hertz, totally enclosed, deadfront, free-standing, modular assembly having vertical and horizontal buses, wireways, compartments equipped with circuit breakers, MCP and starters as shown.
2. Enclosure: Modular assembly allowing maximum of six compartment units in one vertical assembly and units' layout in any combination without structural interference, with the following additional requirements:
   a. Type:
      1) Above ground indoor locations and electrical rooms: NEMA 250, Type 1.
      2) Tunnel areas and underground, except electrical rooms: NEMA 250, Type 12.
      3) Outdoor locations: NEMA 250, Type 3R.
   b. Each unit compartment provided with individual door having concealed hinges. Unit door mechanically interlocked with unit circuit breaker to prevent opening or closing when the circuit breaker is in the ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.
   c. Horizontal wireway with removable coverplate provided at top and bottom for wiring between sections, incoming conduit and cable, motor and control wiring. Top trough separated by barrier from main horizontal bus.
   d. Vertical wireway, with its own door, provided adjacent to each vertical assembly and accessible to two adjacent vertical assemblies when applicable.
   e. Reinforced with adequate steel framework to form rigid structure with smooth outer surface free of burrs, ridges or other blemishes.
   f. Zinc-coated steel sheet: ASTM A653 coating designation G90, minimum thickness 14 gauge
   g. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
3. Horizontal and vertical buses: Main horizontal buses provided at top of structure. Vertical buses for feeding power to each compartment provided in each vertical assembly and securely bolted to main buses.
   a. Busbar: ASTM B187, 98-percent-conductivity copper, contact surfaces tin-plated, fully insulated by extruded sleeve or wound tape.
   b. Each horizontal and vertical bus rated for a minimum of 600 amperes and 300 amperes, respectively, with current density not to exceed 1,000 amperes psi or to meet ANSI temperature of 50-degree rise unless otherwise shown.
   c. Each bus rigidly held by bus supports which have high-dielectric qualities, are moisture-resistant, noncarbonizing and nontracking and have vertical creepage surfaces to prevent faults due to buildup of conductive dirt.
   d. Bus assembly braced to withstand short-circuit rating of 22,000 symmetrical amperes, rms or available short circuit determined by short-circuit calculations, whichever is greater.
   e. Unit guides provided in unit compartment for aligning starter stubs.
   f. Continuous bare-copper ground bus, 1/4-inch by two-inch cross-section, provided throughout length of control center.
4. Motor starter: Across-the-line magnetic or autotransformer starter, as shown and specified, with tin-plated stub assembly for connecting to vertical buses in unit compartment.

5. Circuit breaker:
   a. Main circuit breaker: One 480-volt, three-pole, rating as shown and in accordance with Section 16440.
   b. Branch circuit breaker: One 480-volt, three-pole MCP for each unit compartment.
6. Indicator light: One red light mounted on each unit compartment showing ON position of circuit breaker.
7. Nameplate: As specified under General Requirements for motor starters, with the following additional requirement:
   a. Each motor control center labeled with 1-1/2 inch wide nameplate showing designation in one-inch high characters.
   b. Each compartment labeled with one-inch wide nameplate showing function and number of the motor controlled in 1/2-inch high characters.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Embed iron sills for anchoring motor control center flush with raised concrete pad as shown.

B. Install motor starters and control centers as shown in accordance with manufacturer's recommendations.

C. Install conduit in accordance with Section 16130 and the NEC.

D. Connect power cable and control wire as recommended by manufacturers and as follows:
   1. Make power-cable and control-cable connections to manual starters, across-the-line magnetic starters and autotransformer starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

E. Install motor starters and control centers as shown and in accordance with the NEC and Section 16225.

F. Ground motor starter, complete motor control center in accordance with Section 16060.

G. Apply touch-up paint as necessary.

3.02 TESTING:

A. Furnish necessary equipment and perform the following tests:
   1. Test circuits for connections in accordance with wiring diagram.
   2. Test to ensure that insulation resistance to ground of nongrounded conductor is in accordance with Section 16060.
   3. Test equipment enclosures for continuity to grounding system.
   4. Test operation of circuits and controls.

B. Submit certified test reports.

END SECTION

SECTION 16440

CIRCUIT BREAKERS, PANELBOARDS AND LOAD CENTERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing, installing, connecting and testing of circuit breakers, panelboards and load centers.

B. Related Work Specified Elsewhere:
1. Raceways, boxes and cabinets: Section 16130.
2. Wire, cable and busways: Section 16120.
3. Wire connection accessories: Section 16125.
4. Grounding and bonding: Section 16060.
5. Field painting: Section 09920.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. NEC.
3. NEMA: AB1, PB1, ST20, 250.
4. ANSI: Z55.1.
5. UL: 50, 67, 198C, 489, 891, Electrical Construction Materials Directory.
6. ASTM: A276, B187.
7. ITS: Directory of ITS Listed Products.

B. Source Quality Control:
1. Each item listed per referenced UL or ITS directory.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
2. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each circuit breaker, panelboard and transformer in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage or distortion.

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.
2. Finish for enclosures for enclosed circuit breakers, panelboards, emergency-service panelboards and load centers:
    a. Clean and degrease metallic surfaces.
    b. Prime with zinc primer.
    c. Finish with one coat of light-gray enamel, ANSI Z55.1, Color 61. Minimum dry-film thickness: Two mils.

B. Circuit Breaker: NEMA AB1, UL 489, molded-case, bolt-on, quick-make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic-trip unit. Designed to carry continuous rating in ambient temperature of 40C with the following parameters as shown:
1. Number of poles.
2. Rated voltage.
3. Rated interrupting current.
4. Trip setting.
5. Frame size.

C. Integrally Fused Circuit Breaker:
1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
2. Thermal trip for inverse time-delay overload and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 400 amperes and above equipped with interchangeable thermal and adjustable magnetic trips.
3. Individually removable current limiter, internally mounted on load side of circuit breaker, with rating and time current limiting characteristics that coordinate with time current-tripping characteristics of circuit breakers to provide the following:
    a. Interruption of circuit breaker under fault-current level up to interrupting capacity of circuit breaker.
    b. Interruption by current limiter in conjunction with circuit breaker under fault-current level above interrupting capacity of circuit breaker.
    c. Where necessary to protect downstream panelboard, limit fault current at branch circuit breakers below their interrupting capacity.
    d. Where necessary to protect associated feeder/branch circuits, limit fault current below short-circuit current withstand capability of cable.
4. Removable cover provided over current-limiter section of circuit breaker with interlock for tripping of breaker upon removal of cover and to prevent turning circuit breaker to ON position with cover removed.
5. Equipped with common trip mechanism for tripping all breaker poles simultaneously on blowing of current limiter to prevent single phasing.
6. Capable of interrupting minimum fault current of 100,000-rms symmetrical amperes at 480 volts ac.
7. Circuit breaker rating:
    a. Number of poles: As shown.
    b. Frame size: As shown.
    c. Voltage rating: 480 volts.
    d. Interrupting capacity: As necessary to coordinate with current limiter.
    e. Trip setting: As shown.

D. Enclosed Circuit Breaker:
1. NEMA AB1.

2. Circuit breaker: As shown and as specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.
3. Enclosure:
   a. Galvanized steel, surface-mounted, unless otherwise shown.
   b. Type:
      1) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.
      2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
      3) Outdoor locations: NEMA 250, Type 3R.

E. Panelboard:
1. NEMA PB1, UL 67.
2. Enclosure:
   a. UL 50.
   b. Galvanized steel, surface-mounted unless otherwise shown.
   c. Type:
      1) Aboveground indoor locations and electrical rooms: NEMA 250, Type 1.
      2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
      3) Outdoor locations: NEMA 250, Type 3R.
   d. Gutter size:

Main Bus Rating Amperes	Minimum Top and Bottom Gutter Size in Inches	Minimum Side Gutter Size in Inches
100 and below	4	4
225	6	4
400 and over	8	4

   e. Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.
   f. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
   g. Provision for enclosure grounding.
3. Busbars:
   a. ASTM B187.
   b. 98-percent-conductivity copper.
   c. Contact surface silver-plated or tin-plated.
   d. Rating of neutral and ground bus: Equal to that of phase bus.
   e. Neutral bus mounted on insulating block.
   f. Neutral and ground busbars equipped with integral mechanical connectors.
4. AC panelboards:
   a. Type of service: Three-phase, four-wire, 277/480 volt or 120/208 volt or as shown.
   b. Type of main: Main lugs or circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, located at top or bottom as necessary
   c. Branch circuit: Circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, number of circuits as shown.
   d. Circuit breaker: Trip device coordinated with that of upstream circuit breakers to provide selective tripping.
   e. Suitable for service entrance where necessary.

5. DC Panelboard:
   a. Type of service: 125-volt dc, two-wire.
   b. Type of main: Two-pole circuit breaker, 100-ampere frame, 100-ampere trip and 10,000-ampere interrupting capacity, unless otherwise shown.
   c. Branch circuit: Two-pole circuit breakers, 100-ampere frame and 10,000-ampere interrupting capacity, in accordance with specified requirements, quantities as follows unless otherwise shown:
      1) With 20-ampere trip: Two minimum.
      2) With 30-ampere trip: Two minimum.
      3) With 50-ampere trip: Two minimum.
   d. Enclosure finish: As specified under General Requirements for this section, except color to be OSHA red as specified in Section 09920.
6. Emergency-power panelboard:
   a. NEMA PB1, UL 67, fused-switch.
   b. Enclosure:
      1) Galvanized steel, surface-mounted unless otherwise shown.
      2) Type:
         a) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.
         b) Tunnel areas and underground locations, except electrical rooms and tunnel areas: NEMA 250, Type 12.
         c) Outdoor locations: NEMA 250, Type 3R.
      3) Minimum of four inches side gutter and six inches top and bottom gutter.
      4) Mounting channel drilled and tapped to accommodate any combination of fused switch.
   c. Busbar:
      1) ASTM B187.
      2) 98-percent-conductivity copper.
      3) Contact surface silver-plated or tin-plated.
      4) Rating of neutral and ground bus: Equal to that of phase bus.
      5) Neutral bus mounted on insulating block.
      6) Drilled and tapped to accommodate any combination of fused switch unit.
      7) Neutral and ground bus equipped with integral mechanical connectors.
   d. Type of service: As shown.
   e. Type of mains: Main lugs or fused switch unit as shown, located at top or bottom as necessary.
   f. Branch circuit: Equipped with fused switch unit, number of circuits as shown.
   g. Fused switch unit:
      1) Individually enclosed, quick-make/quick-break switching mechanism.
      2) Equipped with the following:
         a) Silver-alloy contacts.
         b) External operating handle capable of being padlocked in ON or OFF position.
      3) Defeatable door interlock to prevent opening the door when operating handle is in ON position.
      4) Pressure-type fuse with Class J cartridge fuse conforming to UL 198C.
      5) Current rating and number of poles: As shown; maximum rating, 30 amperes.
      6) Use two-pole or three-pole switch unit if single-pole switch unit is not available.

7. Fuse time-current characteristic coordinated with upstream fuse time-current characteristic to provide selective overcurrent tripping.

F. Nameplates:
1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by stainless-steel rivets or screws.
2. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.
3. Each panelboard labeled with nameplate one-inch high bearing ½-inch high inscriptions as appropriate.
4. Nameplate for emergency-power panelboard to bear inscription EMERGENCY POWER.

G. Load Centers:
1. Enclosure:
   a. UL 891, stainless steel, ASTM A276, Type 304, or approved equal.
   b. Type:
      1) Above-ground indoor locations and electrical rooms: Non-ventilated indoor.
      2) Underground locations, except electrical rooms and tunnel areas: Non-ventilated outdoor.
      3) Outdoor locations and tunnel areas: Non-ventilated outdoor.
2. Transformer:
   a. NEMA ST20, dry, self-cooled, epoxy-encapsulated, double-wound with insulated copper conductor with 185C-insulation system capable of withstanding full-wave impulse voltage of 10KV.
   b. Five kVa load center: Single-phase, 60 Hertz, 480 volts primary to 120/240 volts secondary.
   c. Nine kVA load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.
   d. Fifteen kVa load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.
   e. Maximum allowable temperature rise under continuous full load above ambient temperature of 30C and 40C maximum:
      1) By winding resistance: 115C.
      2) By hottest spot in winding: 145C.
3. Circuit breaker:
   a. Bolt-on or plug-in, as specified.
   b. Primary circuit breaker: 480 volts, bolt-on, 14,000-rms symmetrical amperes interrupting capacity, 100-ampere frame, with the following additional requirements:
      1) For five kVa load center: Two-pole breaker with 20-ampere trip setting.
      2) For nine kVa load center: Three-pole breaker with 25-ampere trip setting.
      3) For 15 kVa load center: Three-pole breaker with 40-ampere trip setting.
   c. Secondary main circuit breaker:
      1) Bolt-on, two or three poles as shown, 240 volts, 10,000-rms symmetrical amperes interrupting capacity with trip setting as follows:
         a) For five kVa load center: 25 amperes.
         b) For nine kVa load center: 30 amperes.
         c) For 15 kVa load center: 50 amperes.
   d. Branch circuit breaker:

1) Single-pole, plug-in, 120 volts, 10,000-rms symmetrical amperes interrupting capacity.
a) For five kVa load center: Four breakers, each with 20-ampere trip setting.
b) For nine kVa load center: Six breakers, each with 20-ampere trip setting.
c) For 15 kVa load center: Twelve breakers, each with 20-ampere trip setting.

e. Nameplate: Laminated plastic, one-inch high, attached by means of stainless-steel rivets or screws, showing load-center number in 1/2-inch high white characters engraved on black background.

4. Neutral and ground bus bar equipped with mechanical connectors.

H. Current-Limiting Circuit Breaker:

1. NEMA AB1, UL 489, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
2. Thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt trip device for tripping by ground-fault relay as shown.
3. Limit the fault current, without the use of fusible element, to provide the following:
   a. Protect associated cable by limiting the fault let-through energy to a value below the short-circuit withstand capability of the cable.
   b. Protect downstream panelboard by limiting fault current at branch circuit breakers within their interrupting capabilities.
4. Circuit-breaker rating:
   a. Number of poles: As shown.
   b. Frame size: As shown.
   c. Voltage rating: 480 volts.
   d. Interrupting capacity: Minimum 100,000-symmetrical RMS amperes.
   e. Trip setting: As shown.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install panelboards at locations shown, with bottom not less than 12 inches above floor. Use multiple-section panelboards to meet such spacings if necessary.

B. Mount panelboards and load centers with front straight and plumb.

C. When feeder serves more than one panelboard or panelboard section, install separate junction box or provide adequate gutter area for termination of feeders and bus taps.

D. Install single and/or multiple-conductor cable in accordance with Section 16120. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in panelboard.

E. Install load centers where shown.

F. Make conduit connections in accordance with Section 16130.

G. Make power cable connections to circuit breakers, integrally fused circuit breakers, fused switch units, neutral and ground bus bars in panelboard and load centers and enclosed circuit breakers by means of integral mechanical connectors. If such items are not furnished with

integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

H. Ground panelboards, load centers and enclosed circuit-breaker enclosures in accordance with Section 16060 and the NEC.

I. Apply matching touch-up paint where necessary.

3.02 DIRECTORY OF CIRCUITS:

A. Furnish each panelboard and load center with legibly printed circuit directory located on inside of enclosure.

3.03 FIELD QUALITY CONTROL:

A. Furnish necessary equipment and perform the following tests:
1. Molded-case circuit breakers: Perform pole-to-pole and pole-to-ground insulation resistance tests with 1,000V dc megger. Insulation resistance to be 50 megohms minimum.
2. Panel boards and load centers: Perform insulation-resistance tests of each bus section phase-to-phase and phase-to-ground for one minute using 1,000V megger. Insulation resistance to be not less than manufacturer's recommended minimum or two megohms minimum.
3. Test circuit connections in accordance with wiring diagram.
4. Test panelboard and load-center enclosures for continuity to grounding system.
5. Check cable connections to circuit breakers and fused switch unit for tightness.
6. Check setting of adjustable magnetic trips for compliance with approved coordination study.

B. Submit certified test reports.

END OF SECTION

SECTION 16525

LED INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 16145 "Wiring and Control Devices" for automatic control of lighting, including, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 16060 “Grounding and Bonding”.
3. Section 16125 “Wire Connection Accessories”.
4. Section 16120 “Wire, Cable and Busway”.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include life, output (lumens, CCT, and CRI), and energy efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79 and IES LM-80.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

E. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

F. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

G. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.

2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

F. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of Authority Having Jurisdiction.
2. National Electrical Code (NEC) latest Edition.
3. UL: 94, 8750 Electrical Construction Materials Directory.
4. FS: FF-B-588, FF-P-395, FF-S-325C.
5. MS: MIL-C-450.
6. FED STD: 595.
7. PEI: 1001.
8. SSPC: SP-8, SP-10.
9. ASTM: A53, A167, A276, A123, A507, A575, B26, B85, B117, B136, B137, B209, B221, B244, D635, D1056, D1400, D2240, E136.
10. AASHTO: M314, LTS-4.
11. “Intertek (ETL) Directory of Listed Products.
12. AA: Standard finishes as designated by the Aluminum Association and referenced in NAAMM Metal Finishes Manual.
13. ANSI/IEEE: C62.41.
14. IEEE Publication 587.
15. ANSI Standards.
16. FCC Rules and Regulations, Part 15.
17. NEMA 1
18. AISI
19. IES: RP-20
20. The equipment manufacturer shall maintain an ISO 9001 or ISO 9002 certification.
21. National Fire Protection Association (NFPA) 130, latest Edition.
22. Virginia Uniform Statewide Building Code, latest Edition.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

1.11 REGULATORY REQUIREMENTS

A. Refer to Section 16050 – Basic Materials and Methods for Electrical.

1.12 SUBMITTALS

A. Refer to Section 01330 – Submittal Procedures.

PART 2 - PRODUCTS

2.01 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. Bulb shape complying with ANSI C79.1.

F. Lamp base complying with ANSI C81.61.

G. CRI of minimum 70. CCT of 3000 K (+/-70K)

H. Rated lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Driver must have a power factor (PF) of greater than or equal to 0.90.

L. Connectivity: wired Powerline Carrier (PLC) and/or wireless controller.

M. Regulatory compliance minimum UL recognized for the class. The driver shall be field replaceable with quick connect.

N. Nominal Operating Voltage: 120 Vac or 277 Vac.

1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

O. Housings:

1. Extruded-aluminum housing and heat sink.
   Clear painted finish.

P. Difficult Access: 100,000 operating hours with remote driver if practical.

2.02 CYLINDER

A. Minimum 575 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. With integral mounting provisions.

2.03 DOWNLIGHT

A. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Universal mounting bracket.

C. Integral junction box with conduit fitting

2.04 HIGHBAY, LINEAR

A. Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

2.05 HIGHBAY, NONLINEAR

A. Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Universal mounting bracket.

C. Integral junction box with conduit fittings.

2.06 LINEAR INDUSTRIAL

A. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Housing and heat sink rated to the following:

1. Class 1, Division 2 Group(s) A, B, C and D.
2. NEMA 4X.
3. IP 54.
4. IP 66.
5. Marine and wet locations.
6. CSA C22.2 No 137.

2.07 LOWBAY

A. Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Universal mounting bracket.

2.08 PARKING GARAGE

A. Minimum 2,000 lumens. Minimum allowable efficacy of 75 lumens per watt.

B. Low-profile housing and heat sink.

C. Fully gasketed and sealed. IP 65 rated.

D. Stainless-steel latches.

E. Integral pressure equalizer.

2.09 RECESSED LINEAR

A. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

B. Integral junction box with conduit fittings.

2.10 STRIP LIGHT

A. Minimum 750 lumens. Minimum allowable efficacy of 75 lumens per watt.

B. Integral junction box with conduit fittings.

2.11 SURFACE MOUNT, LINEAR

A. Minimum 750 lumens. Minimum allowable efficacy of 75 lumens per watt.

B. Integral junction box with conduit fittings.

2.12 SURFACE MOUNT, NONLINEAR

A. Minimum 750 lumens. Minimum allowable efficacy of 75 lumens per watt.

B. Integral junction box with conduit fittings.

2.13 SUSPENDED, LINEAR

A. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.14 SUSPENDED, NONLINEAR

A. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

B. Integral junction box with conduit fittings.

2.15 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Clear, UV-stabilized acrylic
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum Insert material housing and heat sink.
2. Clear anodized painted finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.16 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.17 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 16125 "Wire Connection Accessories" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm) Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

D. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

2.18 HANDRAIL

A. Stair handrail: Handrail alloy with stainless steel housing. Vandal resistant access chamber. UL listed for wet locations. Final optic to be reviewed in a mock-up. Finish to be confirmed by WMATA Architect. Mounting type and fixture length to be confirmed by contractor.

B. Optics: 65 or 90 degree beam angle.

C. Lamp: LED, 3000k. 205 lumens per foot, 70 CRI. Shall have tight binning with 2-step macadam ellipse to provide color consistency.

D. Electric: 120volts, 2.54 Watts per foot. 50,000 hour lamp life at 70% of lamp lumen output.

E. Driver: Integral LED driver. 0-10V dimming standard.

PART 3- EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached using through bolts and backing plates on either side of wall] <Insert means of attachment.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.
2. Ceiling mount with pendant mount four-point pendant mount with 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod] [wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 16120 "Wire Cable and Busways for Passenger Stations." for wiring connections.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16125 "Wire Connection Accessories."

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to emergency power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.06 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied

conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of WMATA representative.

END OF SECTION

SECTION 16704

COMMUNICATIONS STANDARD SPECIFICATIONS - INSTALLATION

PART 1 -GENERAL

1.01 SECTION INCLUDES

A. Standard Specifications for Contractor-furnished installation services. These Specifications apply to all Contractor installation services, unless otherwise specified elsewhere in this Contract (i.e. conflicting Specification requirements found in other Specification sections, or on Contract Drawings take precedence over Standard Specifications in this section). Unless otherwise specified, communications, electronics and electrical installations shall be governed by the provisions of the "National Electrical Code, Standard of the National Board of Fire Underwriters for Electrical Wiring and Apparatus." All provisions of this code must be considered applicable, whether specifically mentioned in the body of these Specifications or not. In no case shall the installation in one portion of the system be different from the installation in other portions for similar configurations under similar operating and environmental conditions, unless specified.

1.02 UNIT PRICES

A. Unit Prices include all Required Contractor furnished installation services for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.03 RELATED SECTIONS

A. Section 16706 - Communications System Submittals & Services

B. Section 16710 -Communications Grounding.

C. Section 16721 -Communications Telephone System.

D. Section 16723 -Communications Garage Emergency Telephone System.

E. Section 16727 -Communications Passenger Emergency Reporting System.

F. Section 16731 -Communications Fire and Intrusion Alarm System.

G. Section 16733 -Communications Kiosk System.

H. Section 16771 -Communications Carrier Transmission System.

I. Section 16776 -Communications Fiber Optics System.

J. Section 16791 -Communications Mobile Radio System.

K. Section 16820 -Communications Public Address System.

L. Section 16821 -Communications Automatic Public Address Announcement System.

M. Section 16851 -Communications Passenger Station Closed Circuit Television System.

N. Section 16852 -Communications Parking Garage Closed Circuit Television System

1.04 REFERENCES

A. Federal Communications Commission (FCC) (Specifically Parts 15, 90 and other applicable regulations).

B. National Electrical Code. (NEC).

C. Underwriters Laboratories.(UL).

D. American National Standards Institute. (ANSI).

E. Rural Electrification Administration. (REA).

F. Insulated Cable Engineers Association. (ICEA).

G. Electronic Industries Alliance (EIA).

H. National Electrical Manufacturers Association (NEMA)..

I. Institute of Electrical and Electronic Engineers Association, Inc. (IEEE)..

J. Association of American Railroads (AAR)..

K. WMATA General Provisions and Standards Specifications for Construction Projects.

1.05 SUBMITTALS

A. Submit under provisions of Section 16706.

1.06 CONDUIT PLANT

A. Unless otherwise specified, all wiring in structures and tunnels that is external to equipment enclosures and racks, shall be installed in suitable Intermediate Metal Conduit (IMC), or shall be installed in existing cable tray, underfloor duct, or racked to existing channel inserts on tunnel walls, if space is available and assigned by the Engineer. All conduit and cable installations shall be subject to the approval of the Engineer.

B. Available embedded conduit will be assigned for use by the Contractor when not reserved for other requirements. Conduit cleaning, the construction of conduit extensions or rearrangements, cable rerouting, and the construction of conduit plant to enclose all remaining wiring shall be furnished by the Contractor. Surface conduit construction shall not be permitted in most public areas of stations or in a few other places. Core boring of structures may be required to obtain means of passage during conduit plant construction.

C. Inside diameters of conduit shall be determined by the Contractor, based on the NEC, using the appropriate fill factors for the class of service and number and size of conductors. The proposed conduit sizes shall be submitted to the Engineer for approval. Conduits smaller than 0.75 inch shall not be used.

D. All exposed conduit runs shall be installed parallel to walls, floors and ceilings, whenever possible, except where pitch is required for proper drainage. Conduits shall be rigidly

supported at intervals not to exceed eight feet. Standard one-hole, malleable iron galvanized pipe straps of the proper size shall be used for single conduit runs on concrete surfaces. Where conduits are supported on concrete surfaces, machine-bolt type expansion shields and bolts of the proper size shall be used. All screws, bolts and fittings for conduit supports shall be galvanized or cadmium plated. Stainless steel 304 conduit spacers shall be used for conduits running on flat surfaces. Standard conduit elbows or field bends are permitted; they shall not be less than the minimum radius, as required by the NEC, .

E. Conduits shall be connected to equipment metal enclosures using two locknuts and a bushing, except where conduit hubs are provided. Where enclosures, fittings with openings, or boxes of any type are installed in locations determined by the Authority to be subject to moisture, watertight conduit fittings shall be used. Watertight covers with seals shall be provided, and approved sealant applied to openings to effectively prevent the entry of moisture.

F. All conduit entering Communications Equipment Rooms of passenger stations and yards shall be covered and sealed. Watertight conduit and cable seals shall be used where the building or structure penetration is at a lower elevation than the manhole or below the water table. Details are furnished in the Information Drawings.

G. All terminal ends of conduits shall be provided with insulated metallic bushings.

H. Whenever a conduit or exposed cable enters or leaves a box, it shall be permanently tagged, external to the box, with a plastic tag approved by the Engineer. The tags shall be permanently stenciled with a number which shall identify the conduit or cable with an assigned circuit.

I. All conduits installed shall be free of burrs and other sharp edges throughout the entire length. Conduit fittings or boxes shall be installed in conduit runs, where required, to limit the number of bends to a maximum of three 90-degree bends or equal. All conduits used shall be thoroughly cleared by pulling through a mandrel tool, and shall be blown clean by forcing compressed air through the run before wires or cables are pulled.

1.07 CUTTING AND PATCHING

A. All necessary cutting and patching of existing construction shall be provided by the Contractor for the installation of the equipment and cables.

B. All cuttings shall be of the appropriate required sizes and shapes for the materials, cables and equipment to be installed. All cuttings shall be performed using the appropriate type of tools and equipment for the corresponding surfaces and material. The locations, sizes, shapes, and methods of performance for all cuttings shall be subject to approval by the Authority.

C. All patching shall match existing adjacent construction to the satisfaction of the Authority, using the best possible workmanship of the various trades involved. All required material, compounds, sealants and hardware for all patching shall be provided. Fire wall integrity shall be maintained in appropriate construction.

D. Services shall be provided by the Contractor for the removal and reinstallation of all necessary existing items (i.e., platform tiles, manhole covers) to accomplish the installations. Replacement shall be provided for any removed items that are damaged or missing during the performance of work, at no additional cost to the Authority. Replacements shall be identical in manufacture and type to the damaged or missing items.

E. All existing items and construction (i.e., platform tiles, plenums, ceilings, floors, lighting fixtures, junction boxes, structures, and finishes) that are damaged, changed, or modified in the performance of work shall be restored to their original condition and/or surfaces. Appropriate required material, hardware, paints, finishes, and compounds shall be provided. Any items that are damaged, which are determined to be unrepairable, are to be replaced at no additional cost to the Authority. Replacements shall be identical in manufacture and type to the damaged items.

1.08 JUNCTION BOXES

A. Junction boxes shall be furnished and installed for terminating cable runs and for pulling of cables. Boxes provided in conduit runs, to minimize the number of 90-degree bends in a run, shall be considered junction boxes, although used only for the pulling of cable.

B. All boxes shall be mounted plumb and level and shall be rigidly anchored to the supporting surface. Machine bolt type expansion anchors shall be used to fasten boxes to concrete surfaces where inserts are not otherwise provided. In no case shall bolts of less than 0.25-inch diameter be used. Stainless steel spacers shall be used on bolts to provide a 0.25-inch air space between boxes and mounting surfaces.

C. All boxes shall have a number stenciled on the cover. Numbers shall identify the service of the circuits in the box, as approved by the Engineer.

1.09 CABLE TRAYS

A. Unless otherwise specified, cable tray construction shall be allowed only in Communications Equipment Rooms and other equipment rooms assigned for the installation of significant quantities of communications-related equipment. Tray supports shall be located on eight-foot centers, maximum, and shall be subject to the approval of the Engineer. Sufficient supports shall be provided to keep the loaded cable tray deflection to 0.25 inch maximum at mid-span. Tray supports and trays shall be mounted plumb and level.

B. Tray supports, angle iron, or prefabricated channels shall be anchored to ceilings or walls by machine-bolt type expansion anchors and 0.5-inch minimum diameter bolts. Where cable tray fittings occur in a run, trays shall be supported immediately adjacent to, and on both sides of, the fittings.

C. Trays shall be bolted to support members. Precautions shall be taken to prevent anchoring bolts from damaging cables placed in the trays.

D. Cable tray fill shall not exceed 75 percent of the cross-sectional area of the tray, assuming an area of each cable to be equal to the square of the cable diameter.

1.10 EQUIPMENT MOUNTING

A. Unless otherwise specified, equipment shall be anchored to the concrete walls, floors, or ceilings by machine-bolt type expansion shields and 0.5-inch minimum diameter bolts. The number of bolts shall be adequate to provide a rigid and safe support. Where required, concrete bases or pedestals shall be provided by the Contractor with anchor bolts cast in place for the mounting of equipment. All equipment shall be mounted plumb and level.

1.11 PAINTING

A. All painted areas damaged in route to, or at the installation site, shall be repainted with matching colors by the Contractor. The surfaces of equipment and material not accessible after mounting shall be painted prior to installation.

1.12 WIRE AND CABLE

A. Powdered soapstone or other suitable lubricating medium non-injurious to insulation shall be used, if required, when pulling wires or cables in conduits or ducts.

B. Each conduit, duct and pipe shall be cleaned before installing cables therein. The conduits, ducts and pipes shall be maintained in a clean and dry condition during the installation process up to and including the time which each conduit, duct, and pipe is sealed

C. Wires shall not cross one another when they are pulled into a conduit nor shall the conductors be pulled tight or kinked in conduit fittings or boxes.

D. Cables shall be laid, not pulled, into trays or in troughs provided by others. Cables shall be installed with a minimum amount of crossover in the trays and troughs and shall not be placed tightly around bends. Where cables enter or leave trays via conduits, such conduits shall be rigidly affixed and supported at their ends by suitable brackets and conduit straps from the sides of the trays.

E. Wires and cables shall be permanently tagged with plastic tags at each entry to and exit from all equipment terminal blocks. Tags shall be permanently marked to identify the system in which the wire or cable is used. Tags and markings shall be subject to the approval of the Engineer.

F. All cable pairs, including spares, shall be terminated on connectors, protectors, or line terminating blocks on the MDF.

G. Solder with a minimum of 60 percent tin and 40 percent lead with non-corrosive flux shall be used in soldering wires and cables.

H. The Contractor shall seal all openings through which cable, conduit and cable trays pass. The material used to seal the openings shall be furnished and installed by the Contractor. It shall be a fire retardant, non-toxic material and shall comply with the local fire prevention code.

I. All exposed wires and cables entering or leaving equipment housing or junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.

J. The Contractor shall seal all openings in equipment enclosures and junction boxes where exposed cables enter the enclosure or box. A pliable sealing compound made expressly for the purpose shall be furnished and installed after the cables are in place.

K. Nylon straps shall be furnished and installed for bundling and cabling of conductors where two or more single conductors of the same circuit are run exposed in cable trays or in cable troughs. Straps shall be installed approximately every five (5) feet along the cable run. Wires of multi-conductor cables exposed by the stripping of the cable jacket for termination shall be trimmed in a neat, workmanlike manner and tied approximately every three inches with nylon straps. Care shall be taken in terminating or splicing cable. Removal of insulation shall be done in a manner which does not nick the conductor material. In no case shall the conductor be kinked or bent at sharp angles. Smooth bends shall be utilized.

L. Appropriate exposed cables entering or leaving equipment enclosures and junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.

M. All cables and wires installed in environmental air plenums, cable vaults, and under passenger station platforms shall be placed in appropriately sized electrical metallic tubing (EMT) unless otherwise specified.

N. Appropriate channel inserts, arms and insulators shall be provided to support cables in the manholes of the duct bank.

O. Dewatering and removal of all dirt and trash from trenches, manholes, pull chambers, cable troughs, surface trenches, conduit and duct banks shall be provided prior to, and maintained during, the installation of cables.

P. Cables shall be permanently tagged with plastic tags at each entry to and exit from all junction boxes, cable trays, cable ladders, equipment enclosures, conduits, ducts and pipe. Appropriate identification shall be permanently marked on each tag. These plastic tags shall be provided in two forms: Sleeve and flat. The sleeve form shall be of the heat shrinkable type and shall be properly sized to fit the cable for which it is intended. The sleeve form type may be used on cables with an outer diameter of 1/2 inch or less. The flat form type shall be made of flat sheet stock with slots for installation with nylon tie-wrap fasteners. The markings on the tags shall be provided in a color that will contrast sharply with the color of the associated tags. The plastic tags shall be properly installed.

Q. Low-smoke, low-toxicity (not PVC) plenum rated wire and cable shall be utilized throughout installations of equipment in the Jackson Graham Building Communications Equipment Room (i.e., for cables extending outside of equipment enclosures, for inside plant cables extending to other rooms and floors, but not for outside plant cables extending to areas outside of the building), unless otherwise specified. Exceptions may be allowed by the Engineer when such plenum rated cable is not commercially obtainable only from equipment manufacturers, and when appropriate to avoid potential electrical signal mismatching, or to otherwise improve system performance or reliability.

1.13 DIRECT FIXATION IN TUNNEL AREAS

A. Unless otherwise directed, cables shall be installed along the tunnel walls in an organized fashion within the area allotted for communications cables. Cable crosses shall be kept to a minimum.

B. Channel inserts have been provided by others, mounted on approximately four-foot centers, in the tunnel walls. Stainless steel type fasteners or mounting devices shall be provided to secure the cables to the channel inserts. Cables shall be individually mounted to the channel inserts. Cable shall be secured to each channel insert. The fasteners or mounting devices shall be properly sized to the cable, or shall be adjustable to the proper size to support the cable without undue compression. Prior to cable installation, the channel inserts shall be cleaned and foreign material shall be removed, where necessary.

C. Unless otherwise specified, cables shall be installed on the channel inserts in the space allocated for communications cables.

D. In those areas where the specified locations for cables within the tunnels do not coincide with the channel inserts provided by others, or when channel inserts are not available for communications cables, and as necessary to secure MRS antennas, and other cables,

appropriate type cable ladder with hardware, cement anchors, fasteners, and mounting devices, shall be provided to secure cables to the tunnel structure. Appropriate type cement anchors, fasteners, and mounting devices, shall also be provided to secure cables to the tunnel structure when routed to equipment, equipment housings, junction boxes, terminals, and conduits.

E. Sufficient slack shall be provided in the cables between fasteners and mounting devices to allow for expansion and contraction of the cables without damage to the cables or the fasteners and mounting devices.

F. The Authority is installing Tunnel Ventilation Barriers in the tunnels between passenger stations in the vicinity of some fan shafts. The Contractor shall install communications cables running along the tunnel walls through the cable openings that are provided in the Tunnel Ventilation Barrier structures. Openings are either provided on the side near the cable runs or at the top near the ceiling area of the tunnel.

1.14 CABLE TROUGHS ALONG THE TRACK RIGHTS-OF-WAY

A. Cable troughs along the track rights-of-way are utilized for the installation of Communications cables, Automatic Train Control cables and Traction Power Substation (TPSS) control cables.

B. A vertical metal divider has been installed throughout most of the length of the track right-of-way cable troughs to separate the TPSS control cables from the Automatic Train Control and Communications cables. In some locations, the metal divider has been omitted in favor of a small TPSS-control-cable trough mounted within the regular cable troughs.

C. The following conditions and potential problems with the track rights-of-way cable troughs are noted:
   1. The covers for the cable troughs may not be of uniform length of drilling, i.e., each cover section should be regarded as unique to that particular section of trough.
   2. The pressure of ballast on the outside of all metallic constructed cable troughs may cause the outer side to deflect somewhat when the top covers are removed, a condition which may interfere with reinstallation of the trough covers.
   3. The covers are not watertight.

D. The following required installation services shall be provided by the Contractor when installing cables in the track rights-of-way cable troughs:
   1. Removal of snow, ice, dirt and debris from the metal trough covers to obtain access.
   2. Removal of all the metal trough covers.
   3. Removal of fluids, snow, ice, dirt and debris from the troughs.
   4. Protection of all cables already installed in the cable troughs.
   5. Provision for access to conduits entering the cable troughs (possibility of shifting already installed cables).
   6. Proper reinstallation of the trough covers when cable installation is completed.

1.15 FIBER-OPTIC COMMUNICATION CABLE

A. Splicing of single mode fiber-optic communications cable is authorized only at designated cable terminal locations and in Communications Equipment Rooms (splicing trays or enclosures) at passenger stations and transit yards, and in other approved locations, only when essential to join the ends of one or more standard or larger sized full reels of cable together with one partial reel of cable. Only low loss (0.20 dB or less) fusion type splicing and splicing to factory installed pigtails on connectors will be authorized. Approval of the

exact location and methods utilized to make and protect each splice shall be obtained from the Engineer prior to commencing field work.

1.16 COPPER INSIDE PLANT CABLE

A. Splicing is not authorized in cables within the passenger station limits, or within ancillary structures, garages, parking lots, and transit yard S&I Shop and Operations Buildings.

1.17 COAXIAL, TRIAXIAL AND SPECIAL PURPOSE CABLE

A. Splicing is not authorized in coaxial and triaxial cables, or in cable or cable harnesses designated by equipment manufacturers or the Engineer as "special purpose cable." Properly installed and protected connectors shall be used in lieu of splicing.

1.18 COPPER OUTSIDE PLANT CABLE

A. Outside plant cables extending beyond passenger station limits shall be free of splices, unless approval for splicing is obtained from the Engineer. Approval may be granted for splice(s) in cable runs or CTS cable spans, only if the following conditions exist:

B. No more than one splice in each individual cable run (or individual CTS cable span) shall be authorized except where deemed necessary to join two or more standard sized full reels plus one partial reel of cable together to make up the required length for an individual cable run (or individual CTS cable span) which extends between two cable end terminations.

C. Exception:
   1. Splicing of multi-pair copper CTS cables shall not be allowed within 400 feet of either end of the span.

1.19 SPLICE CASE TYPES

A. Highly durable, watertight splice cases shall be furnished and installed in accordance with the manufacturer's instructions, when splicing is authorized. Filled splice cases shall be utilized when splicing filled cable (REA PE-39 telephone and CTS cable, for example).

1.20 SPLICE CASE (AND FIBER-OPTIC CONNECTOR) TECHNICAL SPECIFICATIONS

A. Splice case (and fiber-optic connector) technical specifications and samples must be submitted to the Engineer for review and approval prior to installation.

1.21 SPLICE CASE PHYSICAL PROTECTION

A. Splice cases must be protected from physical damage and must be accessible (i.e. in manholes, hand-holes, cable troughs, terminal or junction boxes, or other protected locations readily accessible for maintenance purposes.) Splices shall not be placed in conduit.

1.22 MAINTENANCE OF FIBER-OPTIC AND COPPER CONDUCTOR IDENTIFICATION

A. When multi-conductor copper or fiber-optic cables are spliced, the same color code, number and group identification shall be maintained throughout the entire cable run. Conductors and individual fibers shall be clearly identified at both end terminals (or cable ends - if not terminated).

1.23 SIGNAL ATTENUATION, CONTINUITY, CROSSTALK AND GROUNDING

A. Splicing shall be accomplished in such a manner that optical or electrical signal attenuation, discontinuities, or cross-talk, do not appreciably increase as a result of such splicing. Cable shields, armor, and all other metallic elements shall be bonded across splices with copper straps and clamps or other approved hardware, to maintain electrical continuity with less than 0.2 ohm increase in resistance. Grounding for electrical protection shall be accomplished as specified or as approved by the Engineer (or, if not specified or detailed in the Engineer's approval, in accordance with applicable NEC provisions).

1.24 AS-BUILT RECORD DRAWING REQUIREMENTS

A. The Contractor shall clearly indicate the location, size, and type of all splices and terminals on As-Built Record Drawings.

1.25 EQUIPMENT ENCLOSURES AND JUNCTION BOXES

A. All equipment enclosures and junction boxes shall be mounted plumb and level, and shall be rigidly anchored to the supporting surface. Appropriate type expansion anchors and bolts shall be used to fasten the enclosures and boxes to support surfaces. An adequate number of bolts of the proper diameter with lock washers shall be used, but in no case shall bolts of less than 0.25 inch diameter be used. Stainless steel 304 spacers shall be used on bolts to provide a 0.25-inch air space between all enclosures/boxes and mounting surfaces.

B. Where equipment enclosures and junction boxes are to be mounted on walls of material other than concrete, the method of mounting and the hardware to be used shall be approved by the Authority.

C. All junction boxes and equipment enclosures shall have a unique identification stenciled on one exposed accessible surface and on the exterior of the cover. The painted stencil markings shall be applied with a procedure that produces clear, legible letters/numbers without voids and without paint running between the stencil and the surface being marked. The marking paint shall provide a definite contrast with the surface on which it is applied.

1.26 BURIED CABLES

A. When direct burial of cable is specified, the following shall apply:
   1. Only cable and wire specified by the manufacturer to be for direct burial shall be buried.
   2. Cable shall be buried not less than 42 inches below grade and shall be below the frost line. The cable trench shall have a minimum width of 12 inches or three times the cable diameter, whichever is greater. The trench floor shall be free of rock, roots and debris, and shall provide a smooth bed for the cable. A minimum of four inches of sand shall be placed on the trench floor. The cable shall be placed in the trench, on the top of the sand, with slack and without kinks or bends. The cable shall be covered with four inches of sand before backfilling. If the trench spoil is used for backfill, it shall be free of rock, stone and debris. The backfill shall be compacted and leveled at specified grade. At no time shall a communications cable or wire be buried within 12 inches of a power conductor.
   3. The Contractor shall provide all shoring required. The Contractor shall mark the cable trench for future location and identification.

4. No digging below the ties within the trackbed shall be permitted. The trackbed is defined as the area along the track extending one foot beyond the end of each track tie.
5. When it is necessary to drive conduit under the trackbed, Authority approval shall be obtained for each case prior to commencement of work. The request for approval shall include details on the type of conduit, depth below surface and method.
6. All wires and cables shall be tested after installation as detailed in Table 3.22-1 and other applicable specification provisions. Installation Completion Tests shall verify that cable shields and armor are bonded across each splice or junction box authorized (if any), and that twisted pairs maintain their identity and continuity end-to-end without crosses, shorts, opens, transpositions or splits. Insulation resistance tests shall be made either with an insulation resistance test set or a dc megohm meter utilizing a test voltage of 250 Vdc or greater, and shall be made in the presence of the Engineer's representative.

1.27 SPECIAL REQUIREMENTS FOR STAINLESS STEEL CORROSION RESISTANT HARDWARE

A. Except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types in tunnels, tunnel crossovers, along the surface rights-of-way, and in all ancillary structures that are open to tunnels (vent shafts, fan shafts, pumping stations, etc. - excluding rooms within these areas that are heated/air conditioned) shall consist of stainless steel 304 material. Also, except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types; in platform plenums (and including track side walls and under-platform slab and extensions into service rooms); along station train room safety walks, in stairways, corridors, and plenums that are not heated/air conditioned; and in all shafts to the surface and dome reliefs, escalator well ways, elevator pits and surface elevator shafts, shall consist of stainless steel 304 material.

B. Exception: Galvanized conduit may be used with stainless steel 304 mounting hardware. Electronic equipment connectors, and other relatively small sized specialty items that are not available in Stainless Steel 304 material may be allowed by the Engineer as exceptions (Ref. Article 3.1 Request for Approval Of Minor Technical Specification Deviation).

C. Unless otherwise specified, stainless steel equipment enclosures, cabinets, and boxes with dull gray colored epoxy paint applied shall be utilized in areas where surface glare may be visible to rail car operators, to avoid glare.

D. Definitions: "Hardware" includes bolts, screws, clamping devices, anchoring devices, threaded rods, nuts, washers, hangers, covers/wall plates etc. "Boxes" includes junctions boxes, outlet boxes, disconnect switch boxes, circuit breaker boxes, and terminal boxes, etc. "Cabinets" includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panelboards. (Note: Definitions include, but are not limited to, the items listed herein.)

TABLE 3.22-1

INSTALLED CABLE AND WIRE CONTINUITY
INSTALLATION RESISTANCE AND MISCELLANEOUS TEST REQUIREMENTS

Application	Type(s)/ Characteristics	Continuity	Required Minimum Reading Calculated Value
(Tunnel, wall shaft, duct bank and direct burial outside plant applications - terminal-to-terminal, including extensions through en-trance conduits and to inside terminal(s)).	Jacketed, armored, shielded, filled, twisted multipair cable with or without compartmentalized core	Conductor loop resistance, each pair:	±7%
		Shield resistance, each:	±15%
		Armor resistance, each:	±20%
		Insulation Resistance	Megohms
		Conductor to Conductor (all):	
		Conductor (all) to core separator and shield:	
	With Compartmentalized Core	Shield to armor:	500
		Armor to ground:	500
	Without Compartmentalized Core	Armor to ground:	500
		Continuity	50
	Jacketed, shielded, filled or nonfilled, twisted multipair cable	Conductor loop resistance, each pair:	100
		Shield resistance, each:	Calculated Value ±10%
	Jacketed coaxial cable, single center conductor plus shield(s)	Continuity	±20%
		Conductor resistance, each:	
		Shield resistance, each:	
		Insulation Resistance	
		Conductor to shield:	Calculated Value ±10%
		Shield to shield(s) - if applicable:	±20%
		Outer shield to ground:	Megohms
	Insulated wire, 600 volt or less rating		100
		Continuity	
		Conductor resistance:	
		Insulation Resistance	100
		Conductor to Conductors (all) - if applicable:	30
		Conductor (each) to ground:	Calculated Value ±10% Megohms
			10
			10
	Measurement Description		

NOTES:

1. Additional tests may be required in accordance with other applicable Specification provisions.

2. The Authority may require the testing, or may elect to re-test, the insulation resistance of tunnel wall, duct bank, or direct burial outside plant cable during periods of high dampness or high ground water. Any single failure to obtain the minimum required readings shall be considered conclusive in determining that defects requiring Contractor repair or replacement are present.

3. Disconnect grounded and terminated cable elements as necessary to facilitate testing.

4. Full information concerning the type, application, to/from terminal destinations, junction boxes/splices (if any), size, conductor size, and actual installed length, must be included on test data sheets for each cable tested.

5. Notwithstanding manufacturers specifications or REA standards, cable(s) that does not meet minimum readings specified shall be replaced by the Contractor, at no additional cost to the Authority.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 16705

COMMUNICATIONS STANDARD SPECIFICATIONS - EQUIPMENT AND MATERIAL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Standard Specifications for Contractor-furnished equipment and materials. These Specifications shall apply to all equipment and materials furnished, unless otherwise specified elsewhere in this Contract (i.e. conflicting Specification requirements found in other Specification sections or on Contract Drawings take precedence over Standard Specifications in this section).

1.02 UNIT PRICES

A. Unit Prices include all Required conduits and fittings, wiring, and cabling to provide rack, cabinets and enclosures for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.03 RELATED SECTIONS

A. Section 16706 - Communications System Submittals & Services

B. Section 16710 - Communications Grounding.

C. Section 16721 - Communications Telephone System.

D. Section 16723 - Communications Garage Emergency Telephone System.

E. Section 16727 - Communications Passenger Emergency Reporting System.

F. Section 16731 - Communications Fire and Intrusion Alarm System.

G. Section 16733 - Communications Kiosk System.

H. Section 16771 - Communications Carrier Transmission System.

I. Section 16776 - Communications Fiber Optics System.

J. Section 16791 - Communications Mobile Radio System.

K. Section 16820 - Communications Public Address System.

L. Section 16821 - Communications Automatic Public Address Announcement System.

M. Section 16851 - Communications Passenger Station Closed Circuit Television System.

N. Section 16852 - Communications Parking Garage Closed Circuit Television System

1.04 REFERENCES

A. Federal Communications Commission (FCC) (Specifically Parts 15, 90 and other applicable regulations).

B. National Electrical Code (NEC).

C. Underwriters Laboratories (UL).

D. American National Standards Institute (ANSI).

E. Rural Electrification Administration (REA).

F. Insulated Cable Engineers Association (ICEA).

G. Electronic Industries Alliance (EIA).

H. National Electrical Manufacturers Association (NEMA).

I. Institute of Electrical and Electronic Engineers Association, Inc. (IEEE).

J. Association of American Railroads (AAR).

K. WMATA General Provisions and Standards Specifications for Construction Projects.

1.05 SUBMITTALS

A. Submit under provisions of Section 16706.

PART 2 - PRODUCTS

2.01 EQUIPMENT RACKS

A. Construction: Open Frame, Aluminum 3-Inch X 1.410 Channel, 1/4 Inch Thick.

B. Panel Mounting Size: Standard 19-inch or 23-inch panels.

C. Finish: Baked Enamel.

D. Color: ANSI 61 Gray.

E. Hole Spacing: Standard EIA 1.75-inch vertical rack mounting spaces.

F. Hole Size: No. 12-24.

G. Base Width: 20.25 inches for 19-inch panels and 24.25 inches for 23-inch.

H. Base Depth: 15-inches.

I. Base Mounting Holes: Front-to-back centers of 12.5-inches and side-to-side centers of 16.0-inches and 20.0-inches.

J. Rack Height: Maximum 7.5 feet.

K. Equipment racks shall have a ground bus bar, bolt mounted near the top of the rack, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar drilled and tapped for six connections. The ground bus bar shall be electrically connected to the equipment rack.

2.02 EQUIPMENT CABINETS

A. Construction: Assembled frame with a flush frame base, suitable side panels and top panel, a front door and a rear door.

B. Assembled frame: Zinc plated 14-gauge steel and shall have the required front-to-back stiffeners to distribute the equipment load.

C. Base: Zinc plated 14-gauge steel or greater.

D. Panel Mounting Rails: Drilled and tapped in accordance with EIA Standard RS-310-C.

E. Front Door and Rear Door: 16-gauge steel with a lockable handle.

F. Ventilation: Louvers front door and/or the rear.

G. Finish: Baked enamel/acrylic, gray color.

H. Cabinet Height: Maximum 7.5 feet.

I. Equipment cabinets shall have a ground bus bar, bolt mounted near the top of the rack, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar drilled and tapped for six connections. The ground bus bar shall be electrically connected to the equipment cabinet.

2.03 DISTRIBUTION FRAMES

A. All systems distribution frames, including the Main Distribution Frame (MDF)/Protector Cabinet, shall consist of the required multisection cable terminal housings, top and bottom assemblies for each housing, a hinged end section at both ends of the distribution frame, a lift-out door for each housing, and a fungus resistant solid plywood backboard in each housing. Each housing of the distribution frame shall contain four distribution rings to permit neat installation of wires and cables within the housing.

B. Finish: Baked enamel gray color.

C. Multisection cable terminal housings shall have a ground bus bar installed near the bottom on the plywood backboard, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar. The ground bus bar shall be drilled and tapped for the required ground connections within the housing. The ground bus bar shall be electrically isolated from the distribution frame enclosures.

2.04 JUNCTION BOXES

A. Junction boxes shall be constructed of 12-gauge sheet steel, except for sizes 24-inch x 36-inch and smaller, which shall be constructed of 14-gauge sheet steel. Boxes shall have all seams welded. The boxes shall be finished to be a NEMA Type 4 rating with the door/cover gasket with an oil resistant gasket material and adhesive. Boxes shall be either galvanized, and painted with ANSI 61 gray paint after priming or shall be a phosphatized surface with ANSI 61 gray polyester powder coating applied. Associated hardware shall be constructed of stainless steel. Junction boxes shall be sized to provide ample space for terminating the

wires and cables installed at each location, including terminal blocks and considering the minimum bending radii of cables. Junction boxes exposed to the weather shall have all wire entrances protected from weather and dust with a pliable sealing compound, and shall be equipped with a drain plug.

B. Junction boxes shall be furnished and installed complete with terminals, fittings, mounting brackets, cable supports and all other necessary hardware. All conductors within a junction box (including spares) shall be terminated on terminal blocks. Junction boxes to be used only for the pulling of cable do not require terminals.

C. Where the Contractor furnishes and installs junction boxes as means of terminating cables, cable supports shall be provided in the boxes.

D. The Contractor may request a waiver to use outlet boxes in lieu of junction boxes for specific application(s) in specific locations. The request must be approved by the Authority prior to the purchase of material or the beginning of installation.

2.05 CONDUIT PLANT

A. All conduit, except as noted, shall be intermediate metal conduit (IMC). The rigid metal conduit shall conform to UL Standard Number 6, Rigid Metal Conduit and National Electric Code Article 345 Intermediate Metal Conduit. The exterior surface shall be thoroughly and evenly coated with metallic zinc applied directly to the surface of the steel (electroplated zinc coating). The conduit furnished shall be supplied in nominal 10-foot lengths, threaded on each end with one coupling attached. The intermediate metal conduit, elbows, coupling, and fittings shall be protected by corrosion protection when subject to severe corrosive influences. Conduit fittings selected for removable covers shall be complete with gaskets and blank covers.

B. Flexible conduit shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Engineer and allowed by the National Electrical Code. The flexible conduit shall be constructed of interlocking spiral strip steel of the best quality. The flexible conduit shall be thoroughly annealed and fully coated with metallic zinc. The flexible conduit shall conform to Underwriters Laboratories standards and Federal Specification WW-C-5568. The flexible conduit shall have an extruded liquid-tight neoprene jacket in those locations where the conduit will be exposed to a wet environment, or required by the Engineer for an approved installation. Appropriate type and sized connectors, couplings and fittings supplied or recommended by the manufacturer for the specific flexible conduits shall be provided.

C. Rigid non-metallic conduit shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Engineer and allowed by the National Electrical Code. Unless otherwise specified, the rigid non-metallic conduit shall be classified as heavy wall type construction. Appropriate type and sized connectors, couplings and fittings supplied or recommended by the manufacturer for the rigid non-metallic conduit shall be provided.

D. The Contractor shall furnish systems and facilities and select equipment with features that will allow for the utilization of cables sized to fit existing conduit (if any), or the Contractor shall be required to furnish and install suitable conduit to Authority standards to accommodate the communications cables required.

2.06 CABLE TRAYS

A. Cable trays shall be prefabricated aluminum, open ladder type, approximately 3 inches in depth and shall conform to NEMA Standard VE-l. The width of cable trays shall be determined by the Contractor, but shall be a minimum of 6 inches. Cable tray bottoms shall have rungs on 4-inch centers. Where applicable, a cantilevered single "wall support" type of tray shall be used.

B. The cable trays shall support a 100 pound per linear-foot load, with a maximum mid-span deflection of 0.25 inch when considered as a simple beam with supports on eight-foot centers.

C. Appropriate type and size curved sections, cross sections, tee sections, fittings, accessories and supports shall be furnished in accordance with the manufacturer's recommendations.

2.07 CABLE LADDERS

A. Cable ladders shall be prefabricated aluminum, open ladder type, approximately three (3) inches in depth and shall conform to NEMA Standard VE-1. The width of cable ladders shall be determined by the Contractor to support cables in cable vault or mounted on wall when conduit is not available or conduit is not suitable for installation.

2.08 HARDWARE

A. Unless otherwise specified, all mounting hardware shall be galvanized. Appropriate type mounting hardware shall be provided for the corresponding supporting surfaces.

B. Unless otherwise specified, brackets for the mounting and supporting of equipment and material in passenger station areas, yard buildings and other facility buildings shall be painted. Unless otherwise specified, brackets installed in tunnel or outdoor areas shall be galvanized after fabrication in accordance with ASTM A386.

C. All bolts, nuts and washers for mounting and supporting of equipment within equipment enclosures shall be cadmium plated.

2.09 PAINTING

A. Equipment furnished and installed by the Contractor other than galvanized, copper, plastic and electrical contact surfaces shall be factory painted internally and externally, except as otherwise specified.

B. Paint colors shall be selected to match existing equipment, where applicable, and shall be subject to the approval of the Engineer.

2.10 SPECIAL REQUIREMENTS FOR STAINLESS STEEL CORROSION RESISTANT HARDWARE

A. Except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types in tunnels, tunnel crossovers, along the surface right-of-way, and in all ancillary structures that are open to tunnels (vent shafts, fan shafts, pumping stations, etc. - excluding rooms within these areas that are heated/air conditioned) shall consist of stainless steel 304 material. Also, except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types; in platform plenums (and including track side walls and under-platform slab and extensions into service rooms); along station train room safety walks, in stairways, corridors, and plenums that are not heated/air conditioned; and in all shafts to the surface and dome reliefs, escalator well ways, elevator pits and surface elevator shafts, shall consist of stainless steel 304 material.

B. Exceptions: Galvanized conduit may be used with stainless steel 304 mounting hardware. Gray colored fiberglass boxes may be utilized for Emergency Trip Station(ETS) Telephones (Ref. Article 3.7 for product specifications). Non-metallic mounting hardware may be utilized for tunnel and passenger station Mobile Radio System (MRS) antenna cable mounting (Ref. Article 3.13 for product specifications). Electronic equipment connectors, and other relatively small sized specialty items, that are not available in Stainless Steel 304 material, may be allowed by the Engineer as exceptions (Ref. Article 3.1, Request for Approval Of Minor Technical Specification Deviation).

C. Unless otherwise specified, dull "powder gray" colored Original Equipment Manufacturer (OEM) factory painted exterior surfaces of stainless steel 304 equipment enclosures, cabinets, and boxes shall be utilized in areas where surface glare may be visible to rail car operators, or the Contractor shall neatly apply dull colored epoxy paint to surfaces to avoid glare. McMaster-Carr Supply Company (New Brunswick, NJ) Catalog No. 7892T78 (from Cat. #98) gray primer (or approved equal) shall be utilized for the Contractor applied paint.

D. Definition: "Hardware" includes bolts, screws, clamping devices, anchoring devices, threaded rods, nuts, washers, hangers, covers/wall plates etc. "Boxes" includes junction boxes, outlet boxes, disconnect switch boxes, circuit breaker boxes, and terminal boxes, etc. "Cabinets" includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panelboards. (Note: definitions include but are not limited to the items listed herein.)

2.11 ELECTRICAL

A. All electrical and electronic components furnished in accordance with this Contract shall be:
1. New and free of manufacturing defects;
2. Free of storage and handling damages;
3. Clearly and permanently labeled with value or identification type;
4. Rated to operate at power, voltage, and current levels exceeding, by at least 20 percent, those which the components will be subject to in service, unless otherwise noted;
5. Commercially available;
6. Capable of operating in the environment specified in these Specifications;
7. Identical, if performing the same function; and
8. Selected with tolerance limits such that the equipment fabricated from the components shall not malfunction over the specified system/facility or equipment operating range.

B. The selection of the electrical and electronic components shall be such as to provide maximum convenience and safety to personnel in installing, operating and interchanging a complete assembly or component part. Provisions shall be made to prevent personnel from accidentally coming into contact with hazardous voltages. Components shall be selected to prevent reversed assembly or installation of connectors and cables. Cables shall be suitably identified with their mating connections.

C. Any deviation from these requirements and the requirements detailed herein, including those inherent in standard production equipment, shall be subject to the approval of the Engineer.

2.12 TRANSISTORS AND DIODES

A. All transistors and diodes shall carry a Joint Electronic Device Engineering Council (JEDEC) number, shall be available from at least two manufacturers, and shall be silicon. Specially selected transistors and diodes within a type number shall not be permitted.

B. Resistors shall have a maximum tolerance of plus-or-minus 5 percent and shall be rated to dissipate a minimum of 1.5 times the maximum power they will be required to dissipate in operation.

C. Zener diodes used for voltage regulation or reference levels shall be of such rating that they will not be damaged if the entire load is removed abruptly, and shall have a Zener voltage tolerance of plus-or-minus 5 percent or better.

D. Zener diodes used for transient protection shall be of such a rating that they will not be damaged in performing their function within all actual conditions encountered in the operating system/facility.

2.13 CAPACITORS

A. Wet electrolytic capacitors shall not be used. Only dry electrolytic capacitors shall be provided.

B. Capacitors shall have a maximum tolerance of plus-or-minus 10 percent and shall be rated for at least 1.5 times the maximum peak voltage they will be subjected to in operation.

2.14 OTHER SEMICONDUCTORS

A. All other semiconductors shall carry a Joint Electronic Device Engineering Council (JEDEC) number and shall be available from at least two manufacturers. All other semiconductors shall be of the silicon type, unless otherwise approved, in writing, by the Engineer.

2.15 INTEGRATED CIRCUITS

A. All integrated circuits (ICs) shall be available from at least two manufacturers. The Contractor shall take all necessary precautions to ensure that no system or facility using ICs shall malfunction in any fashion due to internally or externally generated noise or cross-talk.

B. Integrated circuits shall not be damaged by the failure or partial failure of any one or any combination of the various supply voltages. Integrated circuits shall not be damaged by overvoltage of 1.4 times the normal supply voltage, or by short circuits on their inputs and/or outputs.

2.16 TRANSFORMERS

A. All transformers provided under this Contract shall be of air-cooled, dry type, unless otherwise approved by the Engineer.

B. Unless otherwise specified, all transformers shall have minimum interwinding and winding to core breakdown voltage of 600 Vdc. Transformers used in electronic circuitry are an exception.

C. Unless otherwise specified, all transformers shall conform to the following requirements:

1. Core laminations shall be grain oriented silicon steel. Maximum flux densities shall be substantially below saturation level. The core volume shall allow efficient transformer operation at 10 percent above the highest tap voltage. All laminations must be core plated or annealed, free of burrs and firmly butted. The core laminations shall be tightly clamped and compressed to provide quiet operation. Transformers shall not emit audible noise in excess of 50 dB referenced to .0002 dynes per sq. cm., at a distance of three feet, while operating at rated voltage and load.
2. Coil conductors shall be continuous with terminations brazed or welded without auxiliary flux material. The entire core and coil assembly shall be pre-dried by heat, impregnated with varnish or other approved compound, and cured at a minimum of 350 degrees F to reduce hotspots and seal out moisture. Coils shall be protected with an outer layer of glass tape or similar quality insulation.

D. Unless otherwise specified, all transformers provided under this Contract shall be equipped with suitably insulated screw terminals for all primary and secondary lead wires. Transformers used in electronic circuitry and video isolation transformers are an exception. Appropriate type video connectors shall be provided for the input and output leads of video isolation transformers.

2.17 POWER SUPPLIES

A. Unless otherwise specified, all power supplies shall have the characteristics and meet the requirements listed herein.

B. Power supplies shall be for continuous duty and shall be rated at a minimum of 120 percent of maximum load at 50 degrees C.

C. Power supplies shall be selected for mounting in a standard 19-inch equipment rack and shall be housed in a metal panel-chassis combination with no exposed electrical connections or wires. Appropriate type terminals shall be provided on the rear of the chassis for the connections of all external input and output power leads. An appropriate sized power cord (internally connected) may be provided for the input power leads.

D. Power supplies shall be selected for natural convection cooling. No supplementary fans or other cooling devices will be allowed.

E. The power supplies shall not be damaged by a sustained input voltage varying from 0 to 150 percent of the rated input voltage. Power supplies shall have current limiting, which shall protect the power supplies from damage due to overload or short circuits. Overvoltage protection shall be contained on those power supplies driving solid-state circuitry.

F. Each power supply shall have an output voltmeter, an output ammeter, and a normally illuminated power light (lamp or LED) mounted on its front cover. All panel mounted indicating, adjusting, and protective devices, or openings for such devices, shall be legible and permanently labeled.

G. Each power supply shall be equipped with a failure alarm device, which shall detect any internal failure that will impair the ability of the power supply to deliver its full rated load. This device shall be normally energized by a small percentage of the rated load current of the power supply. Upon detection of a failure, the failure alarm device shall provide an independent contact closure for an external alarm indication circuit. The contacts shall be wired to appropriate type terminals on the rear of the chassis. In addition, the failure alarm

device shall extinguish the normally illuminated power light on the front cover, when a failure is detected.

H. Unless otherwise specified, all redundant power supplies shall be diode coupled to the loads with the corresponding main power supplies.

2.18 CONNECTORS

A. Connectors shall be provided on wires, multi-conductor cables, coaxial cables, and triaxial cables, when required to permit the connection to or removal of equipment items for maintenance, as determined by the Engineer. In-line connectors shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Engineer. Appropriate type and size connectors shall be provided for the joining, splicing, and terminating of all coaxial cables and triaxial cables.

B. Unless otherwise specified, connectors shall not be required for the termination of wires and cables to those equipment items which contain screw type terminals as the interface connection for wires and cables. Connectors shall not be provided in system distribution frames. Appropriate type mating connectors, recommended by the manufacturers, shall be provided for those equipment items requiring connectors for the interfacing of wires and cables. Appropriate type connector assemblies and mating connectors shall be provided to interface wires and cables to all equipment (including system control panels) in the Kiosk and yard consoles.

C. Appropriate type, size, and rated power connectors (plugs) shall be provided to interface equipment power cords and cables to ac power receptacle strips, ac power outlet assemblies, and ac outlets.

D. Unless otherwise specified, all multi-conductor cable connectors (including those provided for custom-made equipment and control panels) shall consist of a molded plastic connector block equipped to hold the required number of contacts, a protective shell (plastic or metal), a mechanical keying device, a device to grip the external wiring firmly in order to prevent strain on the contacts, and the required solderless contacts (pins or sockets). The pin and socket contacts shall be fabricated from commercial bronze or brass and have a minimum 0.00003-inch gold plating over nickel underplate. The pins and sockets shall be appropriately sized to interface the corresponding conductor sizes that are to be terminated to the connector. Connectors provided on equipment for the interfacing of wires and cables shall be firmly secured to the chassis.

E. All connector assemblies shall be easily connected and disconnected by hand. Tools used to apply connector contacts to wires and cable conductors shall be of the size and type recommended by the manufacturer of the connector.

F. Each connector shall be marked in such a manner that its mating half shall be distinctly identified as being related to each other, but to no other connector within the immediate area. These identification markings shall be applied in such a manner that they will not be obscured or worn off in normal use.

G. All conductors (including spares) within a cable that interfaces with a connector shall be terminated in the connector.

H. All in-line connectors installed in wires and cables located inside structures, within tunnel areas, and all connectors installed to equipment which are not located within rooms of passenger stations, ancillary buildings and yards shall be protected by silicon sealer

coating, enclosed by heat shrinkable tubing (sleeves). This requirement shall be excluded for all connections with a weatherproof classification.

I. All in-line connections installed in manholes, hand-holes, cable troughs or cable trenches (direct burial) shall be enclosed in filler splice cases, utilizing products and methods approved by the Engineer.

J. In-line connection shall not be allowed in conduits, ducts, pipes and cable trays.

K. All locations of in-line connections shall be documented on As-Built drawings.

2.19 RELAYS, SWITCHES AND PUSHBUTTONS

A. All electromagnetic relays shall be plug-in type and secured to their corresponding socket to reduce the effects of shock and extreme vibration. Where applicable, retaining wire springs shall be provided with the relays. The contacts of the electromagnetic relays shall be palladium, silver, or gold plated, or shall be mercury-wetted. All contacts shall be bifurcated and shall have a wiping action. The coil and contacts of each electromagnetic relay shall be enclosed in a protective dust cover. Unless otherwise specified or required for a specific function within the associated circuitry, all double throw contacts shall be break-make type (Form "C").

B. All solid-state relays shall be completely encapsulated in a rugged epoxy case. A minimum of 2500-Vrms isolation shall be provided between the input and the output of all solid-state relays.

C. All relays shall be of the appropriate type (Vac or Vdc operation) and be of the required input control rating for their intended use. The contacts of the electromagnetic relays and the isolated outputs of the solid state relays shall have ratings that equal or exceed the corresponding connected load requirements (voltage and current).

D. Arc suppression circuits shall be provided for all relays used in electronic circuitry. Arc suppression may be built into the relays or provided on the printed circuit cards on which the relays are mounted. All time delay relays shall have solid-state timing circuits.

E. All switch and pushbutton contacts shall be palladium, silver or gold-plated. The contacts shall have a wiping action and shall be rated for their intended use. All switches and pushbuttons shall have a long life expectancy of more than 10,000 operations.

F. Unless otherwise specified, the types of switches (rocker, toggle, etc.), the operation of the pushbuttons and switches (momentary action, maintained action, etc.), and the configuration of the pushbuttons and switches on developed equipment shall be determined by the Contractor and approved by the Engineer. Unless otherwise specified, all pushbuttons and switches on developed equipment shall contain LEDs, if indicators are required. Mechanical interlocking shall be provided when required. Full guard bezel which surrounds the button to help prevent accidental operation and barriers between pushbuttons and switches shall be provided, upon request by the Authority.

G. All switches and pushbuttons on equipment shall be permanently labeled. Labeling of the switches and pushbuttons shall either be provided on the surface of the equipment to which they are mounted or provided on the switches and pushbuttons themselves. All graphics on pushbuttons and switches shall be hot stamped in a color that will contrast with the color of the buttons (lenses).

2.20 TEST POINTS

A. Test points shall be provided for each major function. Labeled test points on printed circuit boards and other plug-in modules shall be accessible while the device is in operation.

2.21 PRINTED CIRCUIT BOARDS

A. All printed circuit boards (cards) shall be constructed of fire-resistant glass epoxy material of NEMA quality FR4 or better. Cards shall have sufficient thickness to permit easy insertion and removal without buckling or breaking and shall be keyed to prevent incorrect interchange. All circuits on the printed circuit boards shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.

B. Boards shall be produced with plated through holes, for component mounting and connecting, and for interfacial connections. If all interconnecting circuitry is confined to one side of the board, the board may be produced with unsupported holes for mounting the components which will be soldered to the pattern side of the board.

C. Printed circuit boards shall be coated with an approved moisture-proofing compound after assembly, except when this requirement is waived by the Engineer, due to non-availability from manufacturers of approved off-the-shelf dust protected equipment units.

D. Each printed circuit board shall be permanently and legibly marked with a unique number identifying that type of circuit board (i.e., model number). In addition, each printed circuit board shall be permanently and legibly marked with a unique serial number.

2.22 LED AND INDICATING LAMPS

A. All indicating lights (LEDs and lamps) shall have a life expectancy of 25,000 hours minimum. All indicating lights shall be operated between 85 percent and 95 percent of their rated voltage.

B. All indicating lights on equipment shall be permanently labeled. Labeling of the indicating lights shall either be provided on the surface of the equipment to which they are mounted or provided on their associated lenses. All graphics on the lenses shall be hot stamped in a color that will contrast with the color of the lenses.

C. Unless otherwise specified, all indicating lights (LEDs and lamps) shall be replaceable from the front of the light assemblies.

D. Unless otherwise specified, all numeric and alphanumeric displays shall be solid state LED display or liquid crystal display. Numeric characters shall be 7-segment type display and alphanumeric characters shall be l4-segment type display. However, a dot matrix display will be considered upon request by the Contractor. Unless otherwise specified, all character displays shall be a minimum of 1/2-inch. Appropriate filters and windows shall be provided.

2.23 METERS

A. Unless otherwise specified, traditional meter movements shall have a full scale accuracy of ±2 percent.

B. All meters shall be of the appropriate type for their intended use; i.e., a meter with an ampere scale shall not be acceptable for the measurement of milli-amperes. All meters shall be legible and permanently labeled.

2.24 TERMINAL BLOCKS

A. All terminal blocks and terminal strips shall be rated for service at 300 volts minimum. All terminal blocks and terminal strips shall be of the appropriate current rating for corresponding terminated circuits. All terminals of the terminal blocks and terminal strips shall be sized to accept corresponding terminated wire and cable conductor sizes (gauges). Resistance of the terminals shall not exceed 0.0002 ohms.

B. Unless otherwise specified, terminal blocks and terminal strips provided in junction boxes, equipment enclosures, system distribution frames, equipment cabinets, and termination facilities shall be of the modular, feed-thru type mounted to a metal channel or be of the single molded construction barrier type.

C. Unless otherwise specified, the modular, feed-thru type terminal blocks and terminal strips shall have pressure clamp contact terminals suitable for solid and stranded wire. Appropriate sized (length) continuous mounting channel shall be provided for each terminal block and terminal strip. Appropriate accessories (end sections, channel clamps, partitions, mounting hardware, etc.) shall be provided for each terminal block and terminal strip. Disconnect apparatus (without removing wires) shall be provided in the terminal assemblies of those terminal blocks and terminal strips, which are utilized in conjunction with protector block assemblies, or otherwise specified within these Specifications.

D. The barrier type terminal blocks and terminal strips shall be constructed of molded fire-retardant thermoplastic with double row terminals. The terminals shall consist of binding head screws, with the two screws associated with each terminal electrically connected with a brass strip. Appropriate mounting hardware shall be provided for each terminal block and terminal strip.

2.25 PROTECTOR BLOCKS

A. Unless otherwise specified, each protector block shall be selected for the termination of two pairs (four conductors). The base of each protector block shall be constructed of molded fire-retardant thermoplastic and shall be equipped with four binding posts and four related screw-in arrester units. The four binding posts shall be connected internally to the corresponding arrester units. Each binding post shall be equipped with two nuts and four beveled washers. A ground plate shall be provided on the face of the base of each protector block between the arrester units. The arrester units shall be 2-electrode gas type and provide 400 Vdc fail-short protection.

B. Multiple protector blocks (two pair type) shall be provided and installed adjacent to each other (vertical rows) for the termination of multi-conductor cables containing more than two pairs.

C. Appropriate length brass or copper mounting and ground bar assemblies shall be provided for the installation and grounding of the protector blocks. Each mounting and ground bar assembly shall have a minimum of two binding posts with appropriate nuts and washers for the termination of ground wires. Appropriate hardware shall be provided to secure and ground the protector blocks to the mounting and ground bar assemblies. Appropriate mounting hardware shall be provided to install the mounting and ground bar assemblies.

D. Unless otherwise specified, all wires and cables that enter/exit the Communications Equipment Rooms of passenger stations and yards to/from the WMATA right-of-way shall be terminated on protector blocks in the Communications Equipment Room. All wires and cables that enter/exit equipment within the WMATA right-of-way and enter/exit remote ancillary buildings shall be terminated on protector blocks at the equipment and in the remote ancillary buildings. All wires and cables that enter/exit yard buildings and other

special buildings shall be terminated on protector blocks in the yard buildings and special buildings. All wires and cable conductors (including spares) shall be terminated on protector blocks at each location. Coaxial cables and triaxial cables are exceptions.

2.26 FUSES AND CIRCUIT BREAKERS

A. All equipment shall be protected by fuses or circuit breakers of the appropriate size. Fuses and circuit breakers shall be readily accessible, surface mounted, on all equipment. Fuse wire within the equipment shall not be acceptable.

2.27 WIRES AND CABLES

A. Only continuously extruded outer jackets free of polyvinylchloride (PVC) and PVC-based compounds shall be furnished on cables provided in these Specifications. Exceptions may be allowed by the Engineer when such cable is not commercially obtainable only from equipment manufacturers, and when appropriate to avoid potential electrical signal mismatching, or to otherwise improve system performance or reliability.

B. All single conductor wire and individual conductors of multi-conductor cables shall be copper and shall be insulated.

C. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form. Individual conductors or twisted pairs in a cable having more than two wires shall be assembled helically and with adjacent layers wound in opposite directions. Twisted pairs shall consist of two individually insulated conductor cables with a length of lay as short as good construction will permit, but not longer than ten inches. Where more than one twisted pair is included, length of lay of adjacent pairs shall differ by at least one-half inch.

D. Unless otherwise specified, all multi-conductor cables installed within the WMATA right-of-way shall contain a metallic shield and a corrugated metallic tape armor. The shield and armor shall be separated by an inner jacket.

E. Multi-conductor cables containing more than two conductors shall contain 20 percent spare conductors, or two spare conductors (two spare pairs if composed of twisted pairs), whichever is greater.

2.28 HOOK-UP-WIRE

A. All wiring within electronic equipment selected, or wired by the Contractor shall have passed the Underwriters Laboratories VW-I Vertical Flame Test. The wire size shall be commensurate with the application.

B. All wires within electronic subassemblies and assemblies shall be identified by adequate color-coding, in accordance with best commercial practices.

2.29 GROUNDING

A. Communications systems and facilities, equipment and cables shall be grounded using a single-point grounding scheme. Each Communications Equipment Room will have a separate isolated ground bus bar, provided by others, designated as "communications ground."

B. Unless otherwise specified, the shields of all single shielded communications cables, the shields of multi-conductor cables that have individually shielded pairs, and the inner shield of all double shielded communications cables and communications cables with separate shield and armor, shall be grounded only at a single point and only to the "communications ground." These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes.

C. The outer shield of all double shielded communications cables and the armor of all communications cables with separate shield and armor shall be grounded only at a single point in each cable section. The single point ground shall be located at the end of the cable section nearest to the associated Communications Equipment Room. Cable sections originating at Communications Equipment Rooms shall have the outer shield or armor grounded to the "communications ground."

D. The Contract Drawings show details of the cable grounding scheme.

E. Equipment racks and equipment cabinets shall be electrically isolated from the building structure, adjacent equipment racks and equipment cabinets. Minimum resistance between adjacent equipment racks and equipment cabinets, and between equipment racks and equipment cabinets and the building structure, shall be 10 megohms. Each equipment rack and equipment cabinet shall be individually wired to the communications ground, via the copper ground bus bar on the equipment rack and equipment cabinet, by a No. 6 AWG, stranded, insulated wire, Type XHHW.

F. Each copper ground bus bar in the multi-section cable terminal housings of the MDF/Protector Cabinet and the systems distribution frames shall be wired to the communications ground by a No. 6 AWG, stranded, insulated wire, Type XHHW.

G. All power conductors shall be electrically insulated from equipment racks and equipment cabinets, and power ground shall be separate and isolated from communications ground. Conduit containing power conductors running from ac distribution boxes to equipment racks, equipment cabinets, ac receptacle boxes on equipment racks and equipment cabinets shall be insulated from the equipment cabinet or equipment rack by means of short lengths of non-conducting conduit.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Adjacent equipment racks and equipment cabinets shall have a 0.25-inch separation between upright members. They shall be mechanically secured to each other by 0.25-inch nylon bolts and spacers.

B. Adjacent equipment racks and equipment cabinets shall use rigid non-metallic conduit for interconnecting wiring.

END OF SECTION

SECTION 16706

COMMUNICATIONS SYSTEM SUBMITTALS & SERVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Submittal procedures.

B. Construction progress schedules.

C. Proposed Products list.

D. Product Data.

E. Shop Drawings.

F. Contract Record Drawings

G. Spare Parts

H. Equipment Manuals

I. Training

J. Samples.

K. Design data.

L. Test reports.

M. Certificates.

N. Manufacturer's instructions.

O. Manufacturer's field reports.

1.02 RELATED SECTIONS

A. Division 1

B. Section 16707 - Communications Systems Quality Assurance & Testing.

1.03 REFERENCES

A. AGC (Associated General Contractors of America) publication "The Use of CPM in Construction - A Manual for General Contractors and the Construction Industry."

1.04 SUBMITTAL PROCEDURES

A. Transmit each submittal with Engineer accepted form.

B. Sequentially number the transmittal form. Revise submittals with original number and a

sequential alphabetic suffix.

C. Identify Project, Contractor, Subcontractor or supplier, pertinent drawing and detail number, and specification section number, as appropriate.

D. Apply Contractor's stamp, signed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Work and Contract Documents.

E. Schedule submittals to expedite the Project, and deliver to Engineer. Coordinate submission of related items.

F. For each submittal for review, allow 30 days excluding delivery time to and from the contractor.

G. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

H. Provide space for Contractor and Engineer review stamps.

I. When revised for resubmission, identify all changes made since previous submission.

J. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

1.05 CONSTRUCTION PROGRESS SCHEDULES

A. Submit initial schedule in duplicate within 20 days after date established in Notice to Proceed.

B. Revise and resubmit as required.

C. Submit revised schedules with each Application for Payment, identifying changes since previous version.

D. Submit a computer generated network analysis diagram using the Program Evaluation and Review Technique (PERT) Technique method, as outlined in AGC - The Use of CPM in Construction.

E. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate the early and late start, early and late finish, float dates, and duration.

F. Indicate estimated percentage of completion for each item of Work at each submission.

G. Indicate submittal dates required for shop drawings, product data, samples, and product delivery dates.

1.06 PROPOSED PRODUCTS LIST

A. Within 30 days after date of Notice to Proceed, submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product.

B. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

C. The Contractor shall use the major products described in the Communications Sections when practical, to avoid increasing WMATA's maintenance requirements.

D. If "equal" products are proposed by the Contractor, he shall insure that the proposed products will interface and operate properly with other Contractor-supplied products, subsystems and systems, and with existing communications products, subsystems, and systems.

E. Whenever the Contractor proposes a new major product (one where salient characteristics have been described in any Communications Section) that has not been previously used on the Transit System, the Contractor shall include that new product in his training program to be conducted for WMATA operations and maintenance personnel.

1.07 PRODUCT DATA

A. Product Data For Review:
   1. Submitted to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
   2. After review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article above and for record documents purposes.

B. Product Data For Information:
   1. Submitted for the Engineer's review.

C. Product Data For Project Close-out:
   1. Submitted for the Authority's benefit during and after project completion.

D. Submit the number of copies that the Contractor requires, plus two copies that will be retained by the Engineer.

E. Mark each copy to identify applicable products, models, options, and other data. Supplement the manufacturers' standard data to provide information specific to this Project.

F. Indicate Product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

G. After review distribute in accordance with the Submittal Procedures article above and provide copies for record documents.

1.08 SHOP DRAWINGS

The Contractor is not required to prepare new Shop Drawings for the Kiosk Fabrication. The Contract Drawings specify the details for fabrication of the Kiosk. These Kiosk Fabrication Drawings may be submitted by the Contractor as Shop Drawings, with a notation on each drawing stating that the Contractor has elected not to change the drawing, or with the Contractor's changes clearly marked. Alternatively, the Contractor may elect to submit individual sheets of Contractor developed Shop Drawings, which replace specific Kiosk Fabrication Contract Drawing Sheets.

A. The Contractor shall, unless otherwise directed, submit one reproducible original and four black ink on white paper copies of all communications system shop drawings to the

Engineer for approval using standard transmittal forms in accordance with detailed instructions furnished by the Engineer. Shop drawings shall be 11" x 17" except for drawings designated by the Authority to be full size.

B. The Contractor shall develop an Engineering Drawing Index which shall be submitted to the Engineer for review and approval. The drawing index shall include descriptive titles, drawing numbers, revision numbers, and the dates of completion of drawings for communications systems and facilities covered in these Specifications and for all Contractor-furnished equipment. The Engineering Drawing Index shall be definitive as to the availability and content of subsequent drawings. It shall be compatible in format and drawing number sequence with Authority Drawing Index for previous Communications Contracts and subject to approval .The Engineer shall assign the drawing number sequence. The drawing number sequence shall be 15XXX. The Contractor shall be responsible for maintaining, revising and updating the Engineering Drawing Index for the duration of the Contract. The Engineering Drawing Index shall be revised and updated quarterly, or as required by the Engineer. A completed Final Drawing Index shall be provided to the Engineer at the conclusion of the Contract.

C. Shop drawings shall be complete, detailed and dimensioned. All necessary shop drawings shall be provided for use in fabricating, assembling, handling, erecting, installing, connecting, trouble-shooting, testing, and maintaining each complete system/facility, all changes to existing systems, facilities and equipment, and all equipment furnished, as follows:

1. Equipment installation drawings, including sections, elevations, and floor plans showing dimensions necessary for installation, equipment base or mounting details, and location of entrance/exit for cable(s).
2. Outline drawings indicating overall dimensions, aisle space requirements, locations of all devices mounted on equipment racks/cabinets and panels, locations of all terminal blocks or connectors for connections to external cable, and removable plates for cable entry; sufficient detail shall be provided to show accessibility for maintenance.
3. Complete detail system/facility block and level diagrams for each system/facility and for all equipment that is provided by the Contractor; each block shall represent one specific function, and each apparatus shall be divided into as many blocks as required. Such system/facility diagrams shall also include existing equipment details.
4. Complete cable/wire plan and riser diagrams for each system/facility and all equipment that is provided by the Contractor; including designations, destinations, color codes, and termination details for the conductors of each cable and wire.
5. Separate and complete schematic and logic functional diagrams for circuits of equipment furnished by the Contractor; circuits which are repetitive may be shown as a single schematic and/or logic functional diagram with identical parts indicated. All variations in circuitry must be clearly shown on individual diagrams for each subsystem. Notes which indicate exceptions to typical layout schematics or logics will not be acceptable. Schematic and logic diagrams shall indicate signal flow for all inputs and outputs, bus connections, and all terminal points for external connection. These shall be clearly identified and in agreement with corresponding terminal points on the wiring diagrams. Functional blocks plus their module schematic diagrams on separate drawings will be acceptable for solid-state portions of the logic servicing a specific function. Logic diagrams and schematic diagrams shall conform to the applicable IEEE standards or to alternate approved standards.
6. Interconnecting wiring drawing(s) for each piece of equipment, indicating all terminal points for external cable connections, including cable designations, wire

colors or designations; the number of conductors in each cable; and the destination of each cable, by reference to the appropriate unit and Contractor's drawing number or point device and drawing number as provided in the Contract Drawings.

7. Wiring drawings with all terminals, relays, modules, and other devices shown in their relative physical locations shall be provided. Each drawing shall indicate exact point-to-point connections between interconnected devices and between devices and terminals for external connections. Wire lists and cable running lists will be accepted if they include a description and a diagram of the system/facility. The Contractor shall be responsible for the accuracy of the wiring, terminal point identifications, device identifications, and device designations which shall be in exact agreement with schematic functional diagrams accepted by the Engineer.
8. Schematics and wiring diagrams for all printed circuit boards with all electronic components and test points shown in their relative locations.
9. Both the schematic functional diagrams and the wiring drawings shall indicate all the points essential for troubleshooting, with their respective operating voltage levels, logic state, current, or other applicable measurable parameters.
10. Fabrication and assembly drawings for developed equipment, including panel and chassis layouts, circuit designs, components, graphics, component layouts and list of material.
11. Additional requirements specified in the various Communications Sections.

D. Groups of associated drawings shall be submitted together, so that Authority reviewers can evaluate the composite design and interface considerations involved for specification compliance. Submissions not in compliance with the foregoing requirement may be returned by the Authority without action.

E. Separate drawings shall be furnished for each passenger station, building structure, yard, and site along the right-of-way. Notes which indicate exceptions to a typical drawing for a passenger station, building structure, yard, or site along the right-of-way shall not be acceptable.

F. During construction, (after Shop Drawing approval) the Contractor shall maintain for inspection by the Engineer a record set of Shop Drawings annotated to show all authorized changes incorporated as work progresses. Three set of annotated Shop Drawing shall be submitted not later than three working days after changes are authorized by the Engineer. Information shall include, but not be limited to, the following:

1. Field changes of any type.
2. Changes accomplished by Change Orders (Change Orders may also specify requirements for the prior submission and approval of Shop Drawings before work commences).

G. Before Substantial Completion Inspection (SCI), the Contractor shall furnish to the Engineer one set (2 vellum and 1 black on white paper print) of Shop Drawings for the record, all clearly revised and completed and brought up to date, showing the permanent construction as actually accomplished. Not later than 15 calendar days after Substantial Completion, updated shop drawings shall also be submitted on electronic media (optical compact disk or 3.5 inch magnetic disk) using either AutoCad Version 14 (.DWG) or other Authority approved drawing file formats. In addition to these submission requirements for SCI, additional submissions are required subsequently in accordance with the CONTRACT RECORD DRAWINGS article.

H. Work in the Contract requires modifications, reconfigurations and connections of various existing communications systems and facilities in the passenger stations, transit yards, sites along the rights-of-way and the Jackson Graham Building. Upon request by the Contractor,

and approved by the Engineer, existing Authority Record Drawings may be obtained to incorporate the requirements of this Contract and may be submitted as Contract Shop Drawings. Process for utilizing the Authority Record Drawings shall be in accordance with the requirements of the CONTRACT RECORD DRAWINGS article of this Section.

1.09 CONTRACT RECORD DRAWINGS

A. General:

1. Before the scheduled date of the Final Acceptance of all Contract work, the Contractor shall submit approved as-built mylar original drawings, electronic media, and microfilmed aperture cards for the completed work.
2. As-built drawings shall be on 22 inch by 34 inch Mylar.

B. As-built Drawings:

1. As-built CONTRACT RECORD DRAWINGS shall include Installation Drawings, Shop Drawings, Working Drawings, kiosk data file drawings and revisions to all affected existing Authority Record Drawings.
2. Authority Record Drawings are as-built drawings provided to the Authority in previous communications contracts. The Contractor shall coordinate with the Authority to determine which existing Authority Record Drawings require revisions.
3. The Authority will furnish the original mylars of the Authority Record Drawings which require revisions from which the Contractor shall make reproductions for his use in preparing as-built drawings. Such reproductions shall be on three-mil plastic film for black line Diazo printing, both sides matte, similar to mylar and Estar. Images shall be clear, sharp and readily legible. The original Authority Record Drawings shall be returned to the Authority not later than 10 calendar days after their receipt from the Authority.
4. Revisions to Authority Record Drawings shall match the base drawings in line weights, symbols, and lettering style and size. Drafting shall be performed with AutoCad software, and shall match original Contract Drawings in line weights, symbols, and lettering style and size.
5. The Contractor shall submit three sets of prints of as-built drawings in a timely manner for review and approval.
6. Additions and corrections resulting from Authority review comments shall be incorporated by the Contractor. One mylar original and two copies shall be submitted to the Authority not later than the applicable date specified in the Contract Schedule. Final As-Built Drawings shall also be submitted on electronic media (5 sets of CD-ROM's) using either AutoCAD(.DWG) or other Authority approved drawing file formats.
7. Completed as-built Contract Record Drawings shall bear the signature of an officer of the Contractor's organization, certifying compliance with as-built conditions using a rubber stamp, or electronic facsimile, as follows:

As-Built

Date _____
I certify that this drawing
accurately depicts the work
as constructed.

An Officer of the Company

Signature _____ Title _____
CONTRACTOR'S NAME

1.10 SPARE PARTS

A. This Contract includes the requirement for Communications spare parts. The Contractor shall assure that all spare parts required by this Contract are provided and delivered in accordance with the requirements of Division 1.

1.11 EQUIPMENT MANUALS

A. The Contractor shall furnish Operations and Maintenance (O&M) Manuals for communications systems, as specified in Division 1. The Contractor shall also furnish complete sets of O&M Manuals for each type and variation of Contractor furnished equipment - including all communications equipment and other electronic equipment and associated peripheral equipment, of the communications systems (Contractor furnished items only - unless otherwise specified). Sets of manuals shall generally describe the operation, specifications and characteristics, theory of operation, maintenance, and trouble-shooting procedures for each type of equipment. Complete parts lists and detailed information concerning specific equipment options installed at WMATA shall be included in equipment manuals. The communications manuals shall be divided into three (3) categories and will meet the additional requirements, as follows:

1. Volume A Manuals shall consist of system-related manual(s) with contents as specified herein.
2. Volume B Manuals shall consist of equipment-related manual(s) with contents as specified herein.
3. Manufacturers Service Manuals shall consist of the most complete and most extensive manufacturers' service manual sets available for each item of equipment (applicable to test equipment, or as otherwise specified). (No Contractor furnished supplements or oil resistant covers are required for this category of manuals.)
4. Accurate, technically correct, easily understandable, concise text, charts, tables, illustrations, photographs, and drawings; all of which are directly applicable to the subject matter and are highly appropriate for their intended purpose; shall be provided by the Contractor subject to review and approval by the Engineer.
5. Page layouts, formats, spelling and grammar utilized, and reproduction quality, shall be of good commercial quality and shall be subject to review and approval by the Engineer.
6. Dividers with custom printed tab labels shall be provided for each major subsection (1-1, 1-2, 1-3, etc.), and a distinctive type of divider with custom printed labels shall be provided to separate major parts of each multi-part manual.
7. Secure screw-down, or other equivalent manual bindings shall be furnished by the Contractor, subject to approval by the Engineer. Standard 3-ring binders will not be acceptable for these manuals. Binders shall have front or back (preferably both) pockets for convenient document storage, if this feature is available as an option to the binders otherwise approved by the Engineer.
8. Revision Log sheet shall be included in the front of each manual.
9. The Authority will grant access to all available technical documentation pertaining to prior versions of Communication Systems to aid the Contractor in developing Communication System Manuals.
10. The Authority will provide one copy of manufacturer's specification sheets for existing equipment installed in prior systems at the start of the Contract. Most of these Specifications will not be of reproducible quality and will require retyping before including them in the manuals. Whenever good reproductions of manufacturers' specification sheets can be made, especially those with photos or illustrations, their use in manuals is preferred.

B. Adequacy and Completeness

1. Each complete manual set shall contain a significant amount of detail and significant degree of depth of technical content, including all available details for subsystems. Completeness and accuracy to best commercial standards shall be required. Printing, reproduction, drafting, photographs, graphics, illustrations, and organization, shall be to best commercial standards. All manuals shall be written in English. Each individual manual furnished shall be subject to examination by the Authority for Specification compliance. The Engineer will exercise wide latitude in determining Specification compliance, and may reject manual(s) for noncompliance in minor degrees thereof.

C. Volume A System Related O&M Manuals

1. The Contractor shall furnish complete sets of Volume A Manuals for each of the individual systems.

D. Volume B Equipment Related O&M Manuals

1. The Volume B Manuals shall be equipment-related manual(s). Complete sets of the most extensive and complete Manufacturers' Manuals available shall be provided, with contractor-developed supplemental parts lists, data covering specific options utilized at WMATA, etc. - when applicable.
2. As an exception to the requirements stated herein, abbreviated requirements shall apply to all "Test Equipment," and "Additional Equipment" (i.e. only standard Manufacturers' Service Manuals shall be required, in the quantity specified for such equipment).

E. Submittals Required for Each Volume A and Volume B Manual

1. Five copies of sample formats and Table of Contents outlines (with or prior to the Engineering Development Review).
2. Three copies of complete manuals in draft form prior to Installation Completion Testing.
3. See Tables for quantities of final manuals.

Table of Contents Outline with Minimum Content Requirements:
Carrier Transmission System O&M Manual
(Volume A - CTS Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. all types of carrier transmission systems installed in WMATA passenger stations)	1	page (text)

1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior systems installed in WMATA passenger stations)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specifications for the latest system, with major differences for prior versions still in use)	1	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of the WMATA Carrier Transmission System)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of carrier transmission systems in use)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations)	1+	page (text)
1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA carrier transmission systems)	100+ 60+ 92+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts
1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 90 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages	200 (or more)
Total Drawing Requirement, fold-out sizes	10 (or more)
Grand Total of Pages and Drawings Required (minimum acceptable count)	210

Note: The Engineer may allow minor variations to individual section minimum page requirements, when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:
Fiber Optic System O&M Manual
(Volume A - FOS Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. both types of fiber-optic systems installed in WMATA passenger stations)	1	page (text)
1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA passenger stations.)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specifications for the latest system, with major differences for prior versions still in use)	1	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of the WMATA Fiber-Optics System)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of fiber optic systems in use)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations)	1+	page (text)
1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA fiber optic systems)	20+ 10+ 10+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts
1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 60 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	125
Total Drawing Requirement, fold-out sizes	10
Grand Total of Pages and Drawings Required (minimum acceptable count)	135+

Note: The Engineer may allow minor variations to individual section minimum page requirements, when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:
Telephone System O&M Manual
(Volume A - TEL Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. all types of telephone systems installed in WMATA facilities) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1	page (text)
1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA facilities) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specifications for the latest system, with major differences for prior versions still in use) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1+	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of WMATA telephone systems) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of telephone systems in use) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1+	page (text)
1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA telephone systems)	8+ 8+ 8+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts

1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 90 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	260+
Total Drawing Requirement, fold-out sizes	15+
Grand Total of Pages and Drawings Required (minimum acceptable count)	275+

Note: The Engineer may allow minor variations to individual section minimum page requirements when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:
Mobile Radio System O&M Manual
(Volume A - MRS Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. all types of mobile radio systems installed in WMATA facilities) (WMATA will provide brief section on Rail Car radios system.)	1	page (text)
1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA facilities) (WMATA will provide brief section on Rail Car radios system)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specification for the latest system, with major differences for prior versions still in use) (WMATA will provide brief section on Rail Car radios system)	1+	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of WMATA mobile radio systems) (WMATA will provide brief section on Rail Car radios system)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of mobile radio systems in use) (WMATA will provide brief section on Rail Car radios system)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations and yards) (WMATA will provide brief section on Rail Car radios system)	1+	page (text)

1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA mobile radio systems)	8+ 8+ 8+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts) (WMATA will provide brief section on Rail Car radios system)	1+ 4+	page (text) charts
1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version) (WMATA will provide brief section on Rail Car radios system)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 60 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	230+
Total Drawing Requirement, fold-out sizes	15+
Grand Total of Pages and Drawings Required (minimum acceptable count)	245+

Note: The Engineer may allow minor variations to individual section minimum page requirements when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

1.12 TRAINING

A. The objective of the training program shall be to qualify WMATA training instructors, field engineers, and key supervisory personnel to train WMATA maintenance and operating personnel to properly operate, diagnose, troubleshoot and maintain the communications equipment and/or systems provided by, or affected by, work in this Contract.

B. The Contractor shall provide training for Authority training instructors, engineers, key supervisory technical personnel, and a cadre of maintenance personnel. Training in operating and maintaining equipment shall be provided in accordance with these Specifications. Training shall consist of a combination of formal classroom instruction and hands-on equipment training. Classrooms and on-site training locations will be provided by WMATA. All test equipment and tools for training equipment installation and training course work shall be provided by the Contractor, (for both Contractor personnel and WMATA Trainee use) until training is complete.

C. Scope of Training Program

1. The training program shall be devoted to overall system functioning and instruction on key items of equipment. The training shall be a combination of formal and hands-on training, including demonstrations. Training shall be conducted at Authority training facilities.
2. The Contractor shall provide the instruction and training sessions specified herein.
3. As part of the Engineering Development Review, the Contractor shall submit a Training Concept Plan to the Authority for approval. It shall include the subject matter to be covered, a tabulation of the hours of instruction to be provided, and the equipment to be included in the training program. It shall include a list of proposed

Contractor training to be conducted at various Authority facilities and locations. The Authority will select training sessions from this list.

D. Training Course Objectives

1. The Contractor shall develop an individual Training Course designed to cover basic maintenance of the Fiber Optic System using new Training Equipment Mockups supplied by the Contractor.
2. The maintenance course shall provide each student with instruction designed to meet the following objectives:
   a. Understanding of the basic overall operation of the Mockup as it relates to an equivalent installed Passenger Station Communications subsystem.
   b. Understanding of the nature of each of the signal and power inputs and outputs of major Communications equipment items.
   c. Knowledge of the location of all equipment test points and the best strategy for using the test points.
   d. Familiarity with the Operation and Maintenance Manuals, and knowledge of how to contact the equipment manufacturers for parts, and information.
   e. Qualification of the student to begin assuming maintenance (or operations) responsibilities for the system and equipment items.

E. The Contractor's training program shall be conducted by fully qualified instructors. The instructors shall have thoroughly mastered the specific specialized subject matter involved and shall have the ability to impart technical information to others in easily understood terms. The Contractor shall provide a professional resume for each instructor for review and approval by the Authority. Contractor installation, repair and technical personnel shall also be provided to do installation tasks, with WMATA trainee participation (to the extent agreed to by the Engineer).

F. Training Aids and Materials

1. The training shall be organized to make optimum use of Volume "B" O&M Manuals, Contract Specifications and Drawings, approved Progress Review material, approved Contractor Shop Drawings, and the test equipment furnished to the Authority, in accordance with other provisions of this Contract. The Contractor shall furnish all other required training aids and materials necessary for the training program.
2. The Contractor shall provide copies of each Course Outline, copies of each Lesson Plan, copies of Instructor's Guide(s) and copies of Student Work Books. Operations and Maintenance Manuals, Volume "A" System Manuals and Volume "B" Equipment Manuals, furnished by the Contractor, shall be furnished to each student attending the Maintenance Courses, along with additional copies as required.
3. Training materials, such as lesson plans, study guides, and student handouts, as well as training aids, such as transparencies, slides, photographs, dynamic mockups, models for hands-on demonstration training and hardware cut-aways, utilized in the courses shall become property of the Authority.

G. WMATA requires the following training course materials to be delivered by the Contractor, according to the following specifications:

1. An instructor's guide, containing all the information and directions necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separate blocks (or modules) which may be taught individually. The Instructor Guide should contain, at a minimum:
   a. Discussion of student prerequisites (if any);

b. Program overview;
c. Statement of overall program goals;
d. Lesson plans (a session by session outline containing the following):
1) Student learning objectives, stated in measurable terms;
2) Overview of each lesson;
3) Suggested instructional methods/ learning activities;
4) Required equipment and/or resources.

2. Student work books, to include all materials for the student to interact in the learning situation. It shall contain, at a minimum:
a. Program overview/introduction;
b. Statement of overall program goals
c. Learning objectives, stated in measurable terms, that specifically describe desired behaviors or knowledge to be gained;
d. A fully-developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide;
e. Illustrations, charts, or graphics, as needed to enhance text presentation;
f. Problems/questions related to lesson content, as appropriate.

3. Audio-visual aids, (handouts, transparencies, slides, films, and mock-ups used to conduct the Training Courses).

4. Supplemental materials, a functional mockup, or a functional representation, is required of any equipment item which requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or a WMATA approved substitute. All mockups become the property of WMATA.

5. The Contractor shall deliver final copies to WMATA as follows:
a. Two complete sets of training materials that are completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies from which further copies can be made with no noticeable decrease in copy quality.
b. Five copies of all student and instructor materials, to be used for archival purposes in the WMATA Technical Library.

H. The Contractor shall meet the following specifications in instructional delivery.

1. A description of instructor qualifications, resume, curriculum vitae, or other similar credentials must be submitted to WMATA at least 60 days prior to the presentation of training. The description should document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instruction.

2. The course shall include at least 4 hours of instruction for each major system, and at least 1 hour of instruction for each significant minor system/subsystem (course layout and time allotment shall be submitted for approval by the Authority at least 30 days prior to scheduled classes).

3. For the purposes of course development and presentation, contractors should assume all WMATA students are high school graduates (or equivalent), and that maintenance personnel possess the ability to use basic hand tools and electronic test equipment, and that most trainees have some experience with the systems to be taught.

4. Instructors shall include written and/or practical tests in the Training Courses. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/ maintenance skills. Results and student evaluations will be provided to the Engineer on a confidential basis, for WMATA use.

1.13 SAMPLES

A. Samples For Review:
   1. Submitted to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
   2. After review, produce duplicates and distribute in accordance with Submittal Procedures article above and for record documents purposes.

B. Samples For Information:
   1. Submitted for the Engineer's knowledge.

C. Samples For Selection:
   1. Submitted to Engineer for aesthetic, color, or finish selection.
   2. Submit samples of finishes from the full range of manufacturers' standard colors, textures, and patterns for Engineer selection.
   3. After review, produce duplicates and distribute in accordance with Submittal Procedures article above and for record documents purposes.

D. Submit samples to illustrate functional and aesthetic characteristics of the Product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.

E. Include identification on each sample, with full Project information.

F. Submit the number of samples specified in individual specification sections, one of which will be retained by Engineer.

G. Reviewed samples that may be used in the Work are indicated in individual specification sections.

H. Samples will not be used for testing purposes unless specifically stated in the specification section.

1.14 DESIGN DATA

A. Submitted for the Engineer's review.

B. Submit for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents

1.15 TEST REPORTS

A. Submitted for the Engineer's review.

B. Submit test reports for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

1.16 CERTIFICATES

A. When specified in individual specification sections, submit certification by the manufacturer, installation/application subcontractor, or the Contractor to Engineer, in quantities specified for Product Data.

B. Indicate material or Product conforms to or exceeds specified requirements. Submit

supporting reference data, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on material or Product, but must be acceptable to Engineer.

1.17 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Engineer for delivery to Authority in quantities specified for Product Data.

B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

C. Refer to Section 16707 - Quality Control, Manufacturers' Field Services article.

1.18 MANUFACTURER'S FIELD REPORTS

A. Submitted for the Engineer's review.

B. Submit report within 30 days of observation to Engineer for information.

C. Submit for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

PART 2- PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

SECTION 16707

COMMUNICATIONS SYSTEMS QUALITY ASSURANCE & TESTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. These quality control (QC) system requirements define characteristics, in addition to those in Division 1 of the Specification, of the quality control system that must be implemented by the Contractor during the course of Communications System design, equipment procurement, factory testing, installation and acceptance testing.

B. The Contractor shall provide and maintain a Quality Assurance Plan, and an Inspection and Testing Plan covering the equipment, materials, and services specified herein.

C. The CQCS Quality Assurance Program, Quality Assurance Plan, and Inspection and Testing Plan, including related directives, procedures, processes, instructions, forms and schedules, shall be submitted to the Engineer for approval. The basis for approval shall be the Engineer's acceptance of a document describing how the Quality Assurance Program requirements, set forth herein, shall be met and the acceptance of the form and substance of each document submitted for approval. The approved program and plans shall be used by the Contractor in the performance of any inspection of the equipment, materials and services being furnished. If program/plans are returned as unacceptable, the Contractor shall revise and resubmit the Quality Assurance Program or plans to the Engineer within 30 calendar days.

D. The basis for this quality control (QC) system requirements are the American National Standards Institute (ANSI) Standard ANSI/ISO/ASQC Q9002-1994 entitled "Quality Systems -Model for Quality Assurance in Production and Installation and Servicing.." Quality control systems based on other standards may also be acceptable provided they contain elements that meet these requirements.

1.02 RELATED SECTIONS

A. Division 1

B. Division 16 - Communications Sections

1.03 REFERENCES

A. American National Standards Institute (ANSI) Standard ANSI/ISO/ASQC Q9002-1994

1.04 DEFINITION OF TERMS

A. Quality Assurance Program: The document containing the Contractor's quality-related policies, practices, procedures and methods, which are utilized to assure compliance with Contract Specifications.

B. Quality Assurance Plan: A document detailing how the Contractor will implement the Quality Assurance Program

C. Inspection and Test Plan: A document detailing how the Contractor will inspect and test Contract equipment, materials, workmanship, and services.

D. Inspection: The physical act of verifying, by measurement and examination of the equipment, materials, workmanship, and services, that they conform to approved documents and established quality requirements.

E. Audit: An examination of the Contractor's implementation of the approved Quality Assurance Program for the purpose of determining compliance with and conformance to the Quality Assurance Plan and other related documents.

1.05 QUALITY POLICY

A. The Supplier shall establish and document policies to implement quality control systematically in a manner that meets these QC system requirements. These policies shall be revised or amended until they are accepted by the Engineer.

1.06 QUALITY SYSTEM

A. The Contractor shall document and implement a quality control system consistent with the policies accepted by the Engineer. The quality system shall include:
   1. Written procedures and instructions governing the work covered by this contract.
   2. Effective and verifiable implementation of these procedures and instructions.

B. Activities affecting quality shall be prescribed via documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings.

C. Instructions, procedures, or drawings shall include appropriate measurable or otherwise verifiable criteria for determining that important activities have been satisfactorily accomplished.

1.07 ORGANIZATION

A. The submitted Quality Assurance Program document shall be organized as follows:
   1. Name of Contractor and Contract
   2. Revision Dates
   3. Index
   4. Contents

B. The Contractor shall identify the elements of its organization involved with this Contract, including subcontractors and Original Equipment Manufacturers (OEMs), and the scope of responsibility and authority of these parties.

C. Interfaces with OEMs, subcontractors, and WMATA shall be identified and the scope of each group's responsibilities described

D. The responsibility, authority and the interrelation of personnel who manage, supervise, perform and verify work affecting the quality of items intended for WMATA shall be defined, particularly for personnel who must exercise authority to:
   1. Initiate, recommend or provide solutions through designated channels to eliminate identified noncompliance or nonconformance,
   2. Control further processing, delivery or installation of items until the noncompliance or nonconformance has been corrected, and

3. Initiate action to prevent the occurrence of noncompliance or nonconformance.

E. Inspection and testing functions shall have sufficient resources and organizational independence to perform their responsibilities. Except in-process monitoring, they shall not report to the same management as those who performed the work nor have had input as to how the work was accomplished or accepted.

1.08 SCOPE

A. The Contractor shall provide a statement that identifies the functional areas of Contractor work and the locations where such work is performed. The Quality Assurance Program shall apply to all equipment, systems, and services included in these Specifications, except as otherwise stated. The Contractor's functional work area breakdown shall include, but shall not be limited to, management, engineering, procurement, manufacturing, installation, and inspection.

1.09 SUBMITTALS

A. The Quality Assurance documents shall be submitted within 30 calendar days after Notice-To-Proceed. Contractor test and inspection procedures shall be added to the approved Quality Assurance Program within 30 days after they are developed. Details concerning fabrication processes for equipment and systems that require development shall be added to the approved Quality Assurance Program as the development work progresses (within 30 days after they are developed).

1.10 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall establish and implement measures for maintaining the integrity, security, and acceptability of items during receiving, handling, storage, movement or placement of items.

B. The Contractor shall maintain packing and preservation of items to the extent necessary to ensure conformance with this contract until these items are installed. The packaging of items inspected at the receiving point shall be resealed upon completion of the inspection.

C. The Contractor shall provide secure storage areas to prevent loss of, damage to, or deterioration of items pending their use:
1. Items of different types shall be segregated while in storage;
2. Measures shall ensure that the shelf life of items which deteriorate over time are reported, and that those with expired shelf life are scrapped;
3. Special environment, maintenance (when items are stored for long periods), and stacking limits required by the manufacturer shall be observed.
4. In order to detect deterioration, the condition of items in storage shall be checked and assessed at appropriate intervals.
5. Appropriate methods shall be established for authorizing receipt or release of items at these storage areas.

D. Handling
1. The Contractor shall employ qualified personnel, methods and equipment to prevent damage during handling.
2. Handling equipment and rigging shall be periodically inspected, maintained and tested. Load capacities or ratings shall be visible on the equipment; capacities and ratings shall not be exceeded.

3. Operators shall be trained, and, where required by local codes or elsewhere in this contract, certified. WMATA requirements and rules for use of handling equipment shall also be observed at all WMATA properties, leased premises, or construction sites.

PART 2 - PRODUCT

NOT USED

PART 3 EXECUTION

3.01 QUALITY MANAGEMENT

A. The Contractor shall identify and describe the organizational units having responsibility and authority for development, implementation, and management of the Quality Assurance Program. Achievement of quality objectives shall be verified by individuals and organizations that are responsible for checking, inspecting, auditing, or otherwise verifying that the work has been performed satisfactorily.

B. The Contractor shall identify the program for assuring that sufficient records are maintained to provide documentary evidence of the performance of activities affecting quality and for use in managing the Contract. Typical records shall include Quality Assurance plans, procedures, instructions, nonconformance or defect reports, corrective action reports, and such other quality-related documents as are specified in the Contract Specifications.

C. The Contractor shall identify the program for verifying and determining the cause of unsatisfactory product or workmanship quality and for initiating necessary improvements and corrections to preclude repetition. The Contractor's program should extend, when necessary, to the performance of subcontractors and suppliers.

3.02 DESIGN (AND DEVELOPMENT)

A. The Contractor shall prepare and maintain a plan for inspecting the quality of engineering, development, testing, and documentation activities. The Contractor shall identify the procedures, practices, tables, charts and diagrams applicable to the effort.

B. The Contractor shall document the engineering criteria applicable to the product being supplied. Include performance objectives, operating ranges and conditions, requirements for safety, reliability, availability, the requirements (codes, standards, and practices) for materials, fabrication, construction, testing, operation, maintenance, and quality assurance.

C. Studies, to be conducted in support of the engineering (or development) activity, shall be identified by the Contractor. They shall include analysis of allowable "tradeoffs" and alternatives, identification of potential weaknesses, and the appropriate preventative engineering features, operating and maintenance practices, and safety precautions.

D. The Contractor shall identify the program for assuring that specifications, drawings, and other engineering documents will delineate, as applicable:
   1. Materials and methods, including fabrication, construction, installation, inspection, maintenance cleaning, packaging, shipping, handling, and storage.
   2. Traceability of materials, parts, components, and processes through appropriate lot, piece part, serial, or other appropriate numbers.
   3. Product or workmanship acceptance criteria and the checkpoints during the work process for verifying compliance with the criteria.

E. The Contractor shall identify the methods and procedures for defining and controlling engineering interfaces with other project participants and design organizations. The procedures shall cover the exchange of required engineering data, analysis and resolution of engineering interface problems.

F. The Contractor shall identify procedures for controlling release of documents for authorized use.

G. The Contractor shall identify procedures for documenting the reporting, verifying, analysis, and correcting of troubles that occur during development.

H. Design criteria and input, including computer applications software, shall be identified, documented, and their selection reviewed by those responsible for the technical adequacy of the design. In all cases, the names of the preparer, checker, and the date the checker accepted the document shall be shown.

I. Incomplete, ambiguous, or conflicting requirements shall be resolved by those who drew up the design criteria and input and those who approved their selection.

J. The design input obtained from surveys of existing systems, structures, or facilities shall be documented and identified.

K. Design output (calculations, specifications, and drawings) shall be documented as requirements in a clear, logical, and uniform manner.

L. In all cases, the names of the preparer, checker and the date the checker accepted the document shall be shown.

M. Where required by the applicable Code, design standard, or this contract, design output shall be certified and/or sealed by the appropriate professional practitioner.

N. The calculation method or computer program shall be identified (including computer software version). The reference source of special, state-of-the-art, or experimental features that are not widely accepted in the railroad industry shall also be identified and those features briefly summarized.

O. Where the design output is a computer or computer software, specifications, user manuals, and testing and validation files shall be provided. Where the contract conveys to WMATA the license to duplicate, upgrade, repair, and modify the computer or computer code, detailed schematic diagrams, specifications, any special tools, and working standards shall be provided to enable the exercise of the license.

P. The design shall be verified to have met the requirements of this Contract. Design verification shall be documented and may take the form of design review, checking, alternative analysis or calculation, comparison with proven design, or performance of qualification tests and demonstrations. Design verification documentation. (including OEM equipment qualification testing) shall be made available to the Engineer upon request.

Q. The Contractor shall establish and implement measures to identify, control, and assess the impact of proposed design changes (including those from the OEMs) on specified functional, safety, and quality requirements, and added cost and schedule changes are identified and justified.

R. Design changes shall be reviewed, verified and approved in the same manner as the original version. The Contractor shall assign qualified personnel to review and coordinate design changes.

S. The Contractor shall obtain the Engineer's approval of proposed changes prior to implementing these.

3.03 DOCUMENT CONTROL

A. The Contractor shall establish and implement measures to control reports, procedures, contract technical deliverable documents, OEM and subcontractor technical submittals, and other records and information it generates or receives that relate to equipment performance characteristics, qualification testing, factory testing, installation, inspection, and acceptance testing. This control shall ensure that:

1. The latest, approved versions of documents or information described above are available where affected Supplier's activities are performed.
2. Revised documents are redistributed to those who received the previous issue.
3. Superseded or obsolete documents are promptly removed from areas of work and stations where controlled documents must be distributed.
4. Changes are reviewed and approved by the same functions or organizations that performed the original review and approval or their designated successors.
5. A means (such as a list or computerized database) to identify the current revision of instructions, procedures, drawings, specifications, or calculations is available.
6. Communications (memorandums of meetings, requests for clarification, etc.) and reports are issued or responded to in a timely manner.

B. The Contractor shall establish and implement measures to revise and maintain procedures and other records that relate to the performance characteristics, installation, inspection, and testing of components, equipment, or systems in an updated condition. Current as-built condition of equipment shall be retained on file.

C. Purchasing documents shall contain data clearly describing the product ordered, including, where applicable:

1. The type, class, style, grade, or other precise requirements,
2. The title, number designation and revision of specifications, drawings, process requirements, inspection/test requirements and other relevant technical and quality control requirements, including requirements for approval or qualification of product, procedures, process or inspection equipment and personnel.
3. The title, number and revision of any applicable technical and quality standards to be applied to the product.
4. As a minimum, OEMs shall be required to furnish Certificates of Conformance to the design and manufacturing standards specified by the Supplier, together with the equipment supplied.

3.04 PROCUREMENT

A. The Contractor shall identify the procedures for controlling the receipt, inspection, testing, handling, storage, and distribution of received equipment and its protection from damage, deterioration, loss or substitution. Inspection instructions and test procedures shall provide for verification of characteristics required by the Contract Drawings and Specifications, and documentation of results.

B. The Contractor shall identify the procedures for controlling purchased items that do not conform to Specifications. The procedures shall provide for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.

C. The Contractor shall establish and implement measures for obtaining items and services from suppliers or subcontractors that conform with specified requirements:
1. The Contractor shall select its OEMs, subcontractors and other sub-suppliers on the basis of their ability to meet specified requirements
2. Any procurement requirement which differs from those in the selected OEM, subcontractor, or other sub-supplier's proposal or offer is resolved and the resolution incorporated into the purchase order or contract, and
3. Records are maintained to show acceptability of the selected OEM, subcontractor, or other sub-supplier (where available, records of previously demonstrated capability and performance should be provided to show acceptability of the selected supplier).

3.05 MANUFACTURING, FABRICATION, AND ASSEMBLY

A. The Contractor shall identify the procedure and instructions that will be used to assure that fabrication, processing, and assembly operations are being satisfactorily performed.

B. The Contractor shall identify the inspection and test plans that will be applied to all manufacturing activities for the purpose of verifying conformance to procedures and instructions.

C. The Contractor shall identify the method employed for tracing the identity of materials and items throughout fabrication, processing, or assembly operations.

D. The Contractor shall identify the procedures, instructions, and checklists for the control of the fabrication and assembly processes. This shall include such items as shop orders, process sheets, travelers, and inspection instructions, covering all mechanical, electrical, and metallurgical processes. Inspection instructions shall identify the nondestructive examination processes employed.

E. The Contractor shall identify the methodology of the program including record maintenance.

F. The Contractor shall identify the procedures for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.

G. The Contractor shall identify the procedures and instructions for handling, preserving, packing, packaging, storing, and shipping items shipped to the construction site.

3.06 INSTALLATION

A. The Contractor shall identify the procedures, check off lists, and instructions governing receipt inspection of equipment on arrival at the construction site. The Contractor shall include in the procedures the control of non-conforming items.

B. The Contractor shall identify the procedures for on-site configuration control. This shall include the control of drawings, specifications, work instructions, quality-control procedures, inspection instructions, and testing procedures, used in connection with installation.

C. The Contractor shall identify the procedures and work instructions that apply to installation methods, tests, repairs and rework, cleaning and protection.

D. The Contractor shall identify the inspections and tests to be performed to verify installation suitability.

E. The Contractor shall identify the procedures for controlling the on-site identification, documentation, segregation, technical review, and disposition of non-conforming supplies or workmanship.

3.07 INSPECTION AND TESTING

A. The Contractor shall establish and implement a Unified Test Program that will ensure all communications and related systems, equipment, material and services, furnished during the performance of this Contract, meet the technical requirements and standards specified, as well as all performance criteria.

B. As part of the Contractor's area of responsibility for the Unified Test Program, the Contractor will be required to:

1. Develop a comprehensive Test Plan detailing methods and test procedures to be utilized to ensure compliance with all applicable specifications.
2. Develop detailed test procedures for each individual test within each category of testing, except Authority tests.
3. Submit the Test Plan (including Authority System Validation Tests, Substantial Completion Acceptance, and Final Acceptance Programs) and all test procedures to the Engineer for evaluation, review, and acceptance or rejection. Revise and resubmit until acceptance by the Engineer is received.
4. Furnish personnel, calibrated test equipment, tools, and miscellaneous supplies as necessary to perform all tests and retests, and to maintain all systems and equipment during the test period and until acceptance by the Authority.
5. Coordinate Unified Test Program activities with the schedules and activities of other contractors and with the Engineer, to avoid conflicts with Authority operational requirements.
6. Perform tests and inspections as detailed in all approved test procedures.
7. Evaluate test procedure and inspection results and documentation. Prepare detailed test evaluation reports, summary reports and progress reports.
8. Submit all raw test data, test results, evaluations, and summary reports for evaluation, review and acceptance or rejection by the Engineer.
9. Prepare and submit revised test procedures and test plans to correct procedural and technical errors or omissions discovered in those documents, after their initial Authority acceptance.
10. Furnish corrective actions to effect Specification compliance, including: Remedy test program deficiencies, and system, equipment, material, workmanship, and documentation deficiencies promptly upon request by the Engineer.
11. Perform retesting and additional inspections until successful results are obtained, evaluated, and accepted by the Engineer.
12. Participate in Authority Pre-final Inspections, Substantial Completion (if any), and Final Acceptance activities. Clean the equipment and work site, secure the equipment, and remain responsible for prompt repair or replacement in the event of loss or damage until acceptance by the Authority is received. Furnish inventory services and demonstrate system or equipment operation in support of requests by the Authority. Provide support and access so that the Authority Engineers, Technicians, Mechanics and Inspectors can inspect and test any portion of the work during normal work hours.

13. Provide Unified Test Program reports on a monthly basis beginning within 30 days after the Engineer's acceptance of the Test Plan, and continuing until the final completion of all contract work.

C. The performance of each task requirement shall be subject to the Engineer's acceptance of methods, procedures, and results, for Specification compliance, and as to scheduling for the benefit of the Authority.

D. A Preliminary Test Plan shall be submitted to the Engineer for review. Subsequently, the Final Test Plan shall be submitted to the Engineer for review and acceptance or rejection. In the event of rejection or subsequent rejections, corrected re-submissions shall be delivered to the Engineer within 15 days after the receipt of each rejection. An accepted Test Plan shall be required prior to implementing any category of tests except for factory tests and inspections, installation and completion tests, inspections for cable, and associated terminal equipment, which may be accepted on an individual basis for equipment, and materials that are scheduled to be installed or delivered prior to NTP + ###.

E. Detailed test procedures shall be submitted to the Engineer for review and acceptance or rejection. In the event of rejection or subsequent rejections, corrected re-submissions shall be delivered to the Engineer within 15 days after receipt of each rejection. Approved test procedures shall be required prior to commencing any associated test.

F. Each individual test procedure shall include, but not be limited to: An outline of test objectives, detailed step-by-step procedures with required results and allowable tolerances for each measurement or observation, diagrams illustrating all required test set-ups, manufacturer and model number of each unit and accessory item of required test equipment, and further details as may be required by the Engineer to ensure that both Contractor and Authority field forces are presented with a totally comprehensive, understandable and accurate working procedure.

G. The Contractor shall include complete and adequate safety procedures, warnings, and emergency instructions in Test Plans and test procedures, as appropriate. Test procedures shall also include complete examples of test Data Record Forms with required resultant values and allowable tolerances, in accordance with Specification requirements.

H. The Authority reserves the right to perform additional non-destructive tests and inspections at any time during the course of the contract work. Results indicating deficiencies involving noncompliance with Specification requirements will be reported to the Contractor for corrective action.

3.08 DEFICIENCIES

A. If the Engineer determines from test data acquired from any category of test(s) that the system, equipment, materials, technical documentation, or services furnished do not conform to any Specification requirement(s), the Contractor shall recommend appropriate remedial action based on an analysis of test results within fifteen days after receipt of the Engineer's notice of deficiency. When such recommendations relate to engineering deficiencies, the Contractor shall, upon receipt of the Engineer's approval, make the necessary changes to all equipment and documentation of the type to be delivered or previously delivered (even if previously accepted) during the course of the Contract, at no additional cost to the Authority.

B. When recommendations relate to other deficiencies such as quality control and installation workmanship, the Contractor shall correct all deficiencies at each location, at no additional

cost to the Authority. Retesting after the changes have been completed (Factory Tests and Inspections, Installation Completion Tests and Inspections, and Technical Documentation Verifications) shall be required in whole or part, as determined by the Engineer, at no additional cost to the Authority. If the timely correction of all deficiencies is not completed to effect Specification compliance, as evidenced by the Engineer's acceptance of retest results, the Engineer will initiate remedial actions to the benefit of the Authority. Such actions may include the exercise of warranty, correction of deficiency, delay of payments, disputes or default, and termination actions, in accordance with the General Provisions, or actions of benefit to the Authority, in accordance with any combination of these and other Specification provisions.

3.09 CATEGORIES OF TESTS

A. Tests and inspections shall be required in each of seven categories, as listed below:
   1. Factory tests and inspections, including factory certifications and factory calibration certifications.
   2. Installation completion tests and inspections.
   3. System and integration tests.
   4. System validation tests and evaluations (Authority Conducted Program).
   5. Substantial Completion acceptance tests and inspections (if any) (Authority Conducted Program).
   6. Technical documentation verification inspections.
   7. Final acceptance tests and inspections (Authority Conducted Program).

B. Each test and inspection in each category shall be comprehensive, so that sufficient test result data and inspection result data is furnished to permit complete detailed examination and evaluation, as determined by the Engineer.

C. Additional specialized testing shall also be furnished, as defined in individual system specification Sections .

D. Retesting, and the acceptance or rejection of test results, documentation, and evaluations, shall be within the discretion of the Engineer.

3.10 FACTORY TESTS AND INSPECTIONS

A. All equipment and materials, including custom developed Additional Equipment and any custom developed Test Equipment, furnished in accordance with these Specifications, shall be subject at all times and during all stages of manufacture and assembly, to inspection, test, and rejection by the Engineer. The Engineer may elect to accept factory or Contractor certifications in lieu of complete test result data for certain items when, 1) a WMATA accepted factory test has been previously conducted on one or more production samples or identical deliverable products, 2) the same brand and model of the product to be furnished has proven reliable in Authority revenue service for one year or more, or 3) to simplify test program administration when not adverse to achieving Test Program objectives.

B. Before offering items for inspection or test, the Contractor shall furnish a complete set of applicable drawings for Authority use including, but not limited to, schematics, wiring diagrams, major assembly drawings, manufacturing drawings for custom developed equipment, and detailed specifications for the equipment and materials to be tested.

C. The Contractor shall submit Factory Test and Inspection Plans and Procedures to the Engineer for review. Tests required shall be performed at the point of manufacture and the

point of assembly before shipment to the field. The Contractor shall furnish additional testing by an independent testing laboratory if the manufacturer's Factory Test Plan or Procedures are determined by the Engineer to be inadequate to verify Specification compliance (a maximum of three major items may be designated by the Engineer for independent laboratory testing at no additional cost to the Authority).

D. After the Engineering Development Review for each system has been submitted and approved by the Engineer, Factory Tests and Inspections shall be scheduled for major items, custom prototypes, and other items of equipment and material designated for such testing by the Engineer, to verify compliance with environmental criteria, quality assurance, specified performance, grade of components, reliability, and workmanship including manufacturing processes. The Contractor shall advise the Engineer, in writing, when manufacturing of equipment begins and again two weeks prior to date of scheduled inspection or tests.

E. A "Report of Factory Visit" for the purpose of confirmation and subsequent agreement of any decisions made on site shall be prepared by the Contractor and submitted to the Engineer ten working days subsequent to each factory visit by the Contractor, Engineer, or designated Authority Representative. Each report shall include the purpose of the visit, summary of tests performed and decisions made or required prior to factory certification and shipment.

F. Two copies of test results certified by the manufacturer or an independent laboratory shall be furnished to the Engineer for review and acceptance or rejection prior to shipment. Equipment shall not be shipped before the factory test results have been accepted by the Engineer. Optionally, the Authority may elect to accept Contractor certified test and inspection results in lieu of manufacturer or independent laboratory certified test results.

G. A 200 hour burn-in period (power on - attended or unattended) shall be required for all units of electrically operated and powered custom-made major items of equipment prior to installation, in accordance with instructions from the Engineer. Each unit of custom made equipment shall be set up and powered on the Contractor's, Subcontractor's, or supplier's premises. Reports of such activity shall be furnished to the Engineer.

H. The Contractor shall assemble all of the rack-mounted equipment for a Passenger Station Communications Equipment Room and test prior to shipment to the installation site.

3.11 INSTALLATION COMPLETION TESTS AND INSPECTIONS

A. Installation Completion Tests and Inspections shall be performed after installation to ensure that equipment and materials were not damaged in shipment and that they are properly installed and functioning in accordance with specified criteria, parameters and good commercial practice. Installation Completion Tests and Inspections shall consist of:

1. Visual inspection with check-off lists to verify the following:
    a. That full compliance with requirements detailed in the General Equipment and Material Standards and General Installation Standards sections of these Specifications has been meet.
    b. That only approved products have been used.
    c. That Factory Tests and Inspections have been satisfactorily completed for major items, as required.
    d. That inventory of major equipment and material items is available and accurate.
    e. That equipment is installed in agreement with approved installation shop drawings.

f. That wire and cable terminations as to location, cable identification, routing, color code, and workmanship have been identified.

g. That Time Domain Reflectometry (TDR) measurements of all coaxial and outside plant cables have been made. Printed TDR records of each coaxial and outside plant cable shall be delivered to the Authority to illustrate the length of cable run (proven by demonstrating an open and a short condition before final termination), and the absence of any detectable faults on each coaxial cable and each outside plant cable pair after installation of the cable.

2. Detailed testing shall be required to demonstrate that material and equipment installed meet the criteria and possess the characteristics and parameters contained in the Contract Specifications; including additional requirements and stated tolerances that are specified in Contractor engineering and product approval data submissions and in manufacturer's published specifications attributed to approved products.

B. The testing of all items of equipment and material shall include electrical, mechanical, operational, and functional parameters. Such parameters include, but are not limited to: Levels of voltages, currents, power, distortion, noise, cross-talk, insulation resistance, continuity, attenuation (optical and electrical), physical strength, suitability of mounting method, paint and marking quality, graphics quality and style, location of operating controls and adjustments, and maintainability.

C. These tests shall be performed after the installation of material and equipment and shall be in addition to any Factory Tests and Inspections previously performed. The Contractor shall perform all necessary alignments, adjustments, and maintenance prior to requesting the scheduling of Installation Completion Tests and Inspections.

D. The Contractor shall advise the Engineer, in writing, two weeks prior to the date(s) of scheduled tests and inspections. The Engineer will witness these tests. Two certified copies of Installation Completion Test and Inspection data shall be submitted to the Engineer within seven (7) days after test completion for review and acceptance or rejection.

3.12 SYSTEM AND INTEGRATION TESTS

A. System and Integration Tests shall be on-site performance tests to verify that all operating parameters and functions perform as specified and that each system performs as specified in conjunction with each system or subsystem with which it interfaces. The Contractor shall demonstrate that all material and equipment elements of each installed system function together to meet the system criteria specified. Each system shall be powered a minimum of 48 hours prior to commencing system and integration tests. The Engineer shall be notified, in writing, seven (7) days prior to equipment being powered. Failures shall be recorded by the Contractor and findings furnished to the Engineer at the end of the 40 hours. The Contractor shall also include a description of corrective actions taken.

B. The Contractor shall be responsible for meeting all System and Integration Test requirements including testing and documenting interface compatibility and integration with existing Authority-owned systems and equipment.

C. Each and every interface shall be verified as to operation, function, level, and voltage. The Contractor shall test across the interface points; however, these tests shall only be made under the supervision of appropriate Authority personnel. When minor adjustment to, or reconfiguration of, existing equipment is required, the Contractor shall notify the Engineer, in writing, of the required adjustment or reconfiguration. Authority personnel will make the

adjustment or reconfiguration in the presence of the Contractor. The Contractor shall be responsible for the necessary adjustments or reconfigurations of Contractor-furnished equipment to ensure proper functioning, as specified.

D. The successful completion of all specified Factory Tests and Inspections, and Installation Completion Tests and Inspections, including the correction of all outstanding discrepancies and subsequent retesting, is required as a prerequisite to System and Integration Tests.

E. The tests will vary with each specific system. However, each test shall include all operating parameters and functions. Tests shall be conducted on a location-by-location basis with all failures and discrepancies noted. The Contractor shall not engage in further testing until the Engineer has verified that the Contractor has taken necessary corrective action with respect to those failures and discrepancies. The Contractor shall retest after each successive failure and corrective action to verify Specification compliance.

F. The Contractor shall advise the Engineer, in writing, two weeks prior to the date(s) of scheduled tests. Prior to commencing the System and Integration Tests, the Contractor shall provide failures recorded and corrective action taken, at the conclusion of powering equipment a minimum of 40 hours. The Engineer will witness these tests. Two certified copies of System and Integration Test data sheets shall be submitted to the Engineer within seven (7) days after test completion for review and acceptance or rejection.

3.13 MEASURING AND TEST EQUIPMENT

A. The Contractor shall establish and implement measures for the selection, calibration, and control of measuring and test equipment (M&TE) used to determine conformance.

B. M&TE of a range, accuracy, and sensitivity conforming with measurement tolerances specified within this contract shall be selected and used.

C. Calibration procedures shall require M&TE identification and establish frequency of calibration, calibration method, acceptance criteria, records to be generated, and the action to be taken when results are unsatisfactory.

D. M&TE shall be periodically calibrated using certified references traceable to the National Institute of Standards and Technology (NIST), to other nationally recognized standards when no such NIST standards exist, or to a documented standard acceptable to the Engineer when none of the preceding standards exist.

E. The calibration of M&TE shall be checked at prescribed intervals if testing or inspection will continue over an extended period.

3.14 INSPECTION AND TEST STATUS

A. The Contractor shall establish and implement measures to identify and maintain the inspection and test status of systems, equipment or components until these are accepted by the Engineer, to ensure that only purchased items that have passed the required inspection and test have been used.

B. The means for status identification shall be such that the surface of the item is not damaged nor its use impaired. Status identification may also be via inspection records, test software, physical location, or other suitable means, which indicate the conformance or nonconformance of these items with regard to inspection and tests performed.

3.15 CONTROL OF NONCONFORMANCE

A. The Contractor shall establish and implement measures to prevent the inadvertent use or installation of nonconforming items.

B. Procedures shall provide for identification, segregation, documentation, evaluation, and disposition of nonconforming items, define the responsibility and authority for the disposition of nonconforming item.

C. Nonconforming items shall be positively identified and the matter brought to the attention of Supplier's management representative, the Engineer, and the appropriate OEM, subcontractor or sub-supplier.

D. The Contractor shall hold the nonconforming item from further work and, where possible, shall be physically segregated in an area clearly marked, until the responsible parties have provided for the disposition of the item.

E. The disposition of a nonconforming item may be:
1. Reworked (to meet original requirements)
2. Accepted as-is
3. Repaired (to meet an alternative criteria)
4. Re-graded (for alternative use)
5. Rejected, returned to vendor, or scrapped

F. The Contractor shall obtain written approval from the Engineer prior to using a nonconforming item as-is or repairing it to be acceptable to a standard different from the original standard.

G. Nonconforming items that have been repaired or reworked shall be re-inspected or retested by the party responsible for the original inspection or test in accordance with approved acceptance standards before being declared acceptable.

H. The technical details of nonconformity that have been accepted as-is and of any repairs made shall be included in "as-built" documentation.

I. Items for return to vendor shall be removed from the area of work and controls placed to prevent the reuse of the item or any part of it.

J. Rejected or scrapped items shall be removed from the area of work and rendered unusable in a manner that prevents their inadvertent use.

3.16 CORRECTIVE ACTION

A. The Contractor shall establish and implement measures to:
1. Investigate the cause(s) of noncompliance and nonconformance, and identify action(s) to prevent recurrence.
2. Implement corrective action to minimize or eliminate noncompliance or nonconformance.
3. Apply controls over the implementation of corrective action.
4. Incorporate the preventive action into procedures.

3.17 QUALITY CONTROL RECORDS

A. The Contractor shall establish and implement measures to identify, collect, index, file, and store quality control records as required in the Special Conditions of this Contract.

B. Quality control records shall be available at designated, controlled, but accessible areas at work locations. Procedures shall identify the responsible custodians for these records.

C. Quality control records shall be stored and maintained in such a way that they are readily retrievable and provided with a suitable environment that minimize deterioration or damage, and prevent unauthorized alteration or loss.

D. Quality control records shall be legible, reproducible, identifiable with the item involved, and contain the date of origination and identity of the originator, verifier, and/or responsible supervisor.

E. Retention period for quality control records shall be defined, and shall be at least as long as the term required in the Special Conditions of this Contract. Quality control records shall be made available to WMATA or its representative throughout the retention period.

3.18 AUDITS

A. By WMATA

B. Quality audits may be conducted by WMATA or its representatives. Direct access to Contractor personnel, original records, items in process, and facilities where work is performed shall be provided by the Contractor. The Contractor shall ensure, via procurement documents, that such access are also provided by their subcontractors and suppliers.

1. The Contractor shall provide a written response within 15 days after receipt of the audit report, fully describing the methods and timetable by which compliance will be achieved. Deficiencies shall be corrected within 30 days after receipt of the audit report.
2. Any survey, audit or inspection performed by WMATA or its representatives shall not relieve the Contractor of any of the responsibilities under this contract.

C. By The Contractor

1. The Contractor shall carry out a comprehensive system of planned and documented audits to verify whether activities within its scope of responsibility are performed in compliance with applicable portions of this Quality Control system requirements, and to determine the effectiveness of quality control.
2. Audits and follow-up actions shall be carried out in accordance with documented procedures and by qualified personnel. Audit schedules shall be established to ensure coverage of the scope of the quality control system at least once in the life of this Contract.
3. Results of the audits shall be documented and brought to the attention of the personnel having responsibility in the area audited. Management responsible for the area shall take timely corrective action on the deficiencies found by the audit.

3.19 TRAINING AND PERSONNEL QUALIFICATION

A. The Contractor shall ensure that the Quality Policy are understood and implemented by all elements of its organization that affect the quality of the items or services provided to WMATA.

B. When qualified personnel are required by this Contract, personnel qualification shall be based on an appropriate combination of education, training and experience. Where

required by the applicable code or standard, personnel qualification shall also be certified. Appropriate records of qualification, training and certification shall be maintained as quality records.

3.20 STATISTICAL TECHNIQUES

A. The Contractor shall identify any statistical technique to be used for sampling inspections or testing. Acceptance by means of representative sampling shall be in accordance with generally accepted statistical methods.

END OF SECTION

SECTION 16710

COMMUNICATIONS GROUNDING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section describes hardware, and installation methods that the Contractor shall use to insure the installation of a competent grounding system that will avoid/minimize ground-loops, and Electromagnetic Interference (EMI) problems in the operation of the communications systems installed under this Contract. In addition to the methods detailed in this Section, the Contractor shall insure that his crews adhere to all generally accepted installation practices that are meant to minimize interference between communications systems.

B. Equipment and Rack Grounding.

C. Cable Shield Grounding.

1.02 UNIT PRICES

A. Unit Prices include all Required conduits and fittings, junction boxes, wiring, and cabling to provide grounding to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.03 RELATED SECTIONS

A. Section 16705 – Communications Standard Specifications - Equipment & Material.

B. Section 16706 - Communications System Submittals & Services

C. Section 16721 -Communications -Telephone System.

D. Section 16723 -Communications -Garage Emergency Telephone System.

E. Section 16727 -Communications -Passenger Emergency Reporting System.

F. Section 16731 -Communications -Fire and Intrusion Alarm System.

G. Section 16733 -Communications -Kiosk System.

H. Section 16771 -Communications - Carrier Transmission System.

I. Section 16776 -Communications - Fiber Optics System.

J. Section 16791 -Communications - Mobile Radio System.

K. Section 16820 -Communications - Public Address System.

L. Section 16821 -Communications - Automatic Public Address Announcement System.

M. Section 16851 -Communications - Closed Circuit Television System.

1.04 REFERENCES

A. NFPA 130 - Standard for Fixed Guideway Transit Systems

1.05 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical system wiring diagram.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION

A. Ground Communication system and facilities, equipment and cables using a single-point grounding scheme. Each Communication Equipment Room will have a separate isolated ground bus bar designated as “communications ground.”

B. Unless otherwise specified, ground the shields of all single shielded communications cables, the shields of multi-conductor cables that have individual shielded pairs, and the inner shield of all double shielded communications cables and communications cables with separate shield and armor only at a single point and only to the “communications ground.” These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes.

C. Ground the outer shield of all double-shielded communications cables and the armor of all communications cables with separate shield and armor only at a single point in each cable section. Locate the single point ground at the end of the cable section nearest to the associated Communications Equipment Room. Ground outer shield or armor Cable sections originating at Communications Equipment Rooms to the "communications ground."

D. Electrically isolate equipment racks and equipment cabinets from the building structure, adjacent equipment racks and equipment cabinets. Minimum resistance between adjacent equipment racks and equipment cabinets, and between equipment racks and equipment cabinets and the building structure, shall be 10 megohms. Individually wire each equipment rack and equipment cabinet to the communications ground, via the copper ground bus bar on the equipment rack and equipment cabinet, by a No. 6 AWG, stranded, insulated wire, Type XHHW.

E. Wire each copper ground bus bar in the multi-section cable terminal housings of the Main Distribution Frame (MDF)/ MDF/Protector Cabinet and the systems distribution frames to the communications ground by a No. 6 AWG, stranded, insulated wire, Type XHHW.

F. Electrically insulate all power conductors from equipment racks and equipment cabinets, with a separate power ground isolated from communications ground. Insulate Conduit containing power conductors running from ac distribution boxes to equipment racks, equipment cabinets, ac receptacle boxes on equipment racks and equipment cabinets from the equipment cabinet or equipment rack by means of short lengths of non-conducting conduit.

END OF SECTION

SECTION 16728
CALL FOR AID

PART 1: GENERAL

1.01 SUMMARY

A. Call-for-Aid consists of a communications system that integrates the Passenger Emergency Reporting System, the Kiosk Attendant/Passenger Intercoms and the Elevator Intercoms with the centralized state-of-the-art, Voice over Internet Protocol (VoIP) system. The Call-for-Aid shall provide a means of establishing clear and easy to use voice communications between passengers and the Station Manager(s)/Kiosk Attendant(s) for the following purposes:

1. Reporting emergency situations from the passenger station platforms using intercom call-station panels mounted on columns at the station platforms. The Emergency Call Stations on the platform no more than 200 feet apart and shall be clearly visible to the general public.
2. Providing Passenger/Kiosk Attendant intercom facilities using call-station panels mounted on both the “paid” and “unpaid” areas of each station Kiosk.
3. Providing intercom facilities between Kiosk attendants in stations with multiple Kiosks.
4. Providing elevator intercom facilities from inside station elevators using the call-station panel mounted inside the elevator cab.
5. Providing intercom facilities from all elevator machine rooms and elevator landings within each passenger station.
6. Providing elevator intercom facilities within elevator cars and at elevator landings within the passenger stations.
7. Providing intercom reporting emergency situations in the Areas Refuge and Dispersal Areas
8. Providing intercom facilities from all main entrances into the station.
9. Providing a means of connecting a portable Master Station intercom unit to a jack mounted on the top of each elevator car for maintenance communications between the top-of-car (TOC) and the Elevator Machine Room (EMR).
10. Providing call transfer, or roll-over, capability to the Operations Control Center (OCC) through 5 digit DTMF dialing over local stations assigned to the VoIP telephone system in the event a Kiosk station manager does not answer or acknowledge within a predetermined time a call from any of the call stations.
11. Providing a Call-for-Aid Call Station at each entrance pavilion and pedestrian bridge gated entry point.

B. The communication Subcontractor will provide a Master Station for the Kiosk, and remote stations in each elevator, and on each elevator landing. All other components for the Call-for-Aid shall be designed, furnished, and installed under this specification. Design, coordination, integration, and documentation of the Call-for-Aid system shall be accomplished under this specification.

C. The Call-for-Aid shall be a state-of-the-art VoIP system which shall be software-programmable, and shall be supplied with all software, programming devices and training needed for programming or reprogramming.

D. The Call-for-Aid Intercom System shall be easily configurable to meet the varied requirements of the existing Metrorail system and future Metrorail extensions. For example, calls initiated from remote call-stations, within elevator cars, platforms and passenger walkway entrances, areas refuge, dispersal areas and/or from elevator landings could be directed to:

1. Specific Kiosk within a station location.
2. All Kiosks within a station location simultaneously.
3. Kiosk and then to remote-monitoring facilities based on a preprogrammed roll-over sequence through the VoIP telephone system.
4. Remote monitoring facilities immediately, if so desired, through the VoIP telephone system.
5. Call-for-Aid equipment gives the station location to both Rail Operation Control Centers when reporting emergency.

E. The Call-for-Aid shall be capable of handling calls from multiple call stations. The Intercom Master Station at each Station Kiosk shall display the identification code of the originating instrument of each connected incoming emergency call, shall allow scrolling of identification codes of subsequently received emergency calls waiting to be connected, and shall provide a means to switch from one call to another without disconnecting either call, until a call-disconnect button is pushed.

F. The Call-for-Aid system shall be scalable, so that additional remote call stations are easily added into the Call-for-Aid system, and supported by programming the VoIP call manager server and the Kiosk Master Station.

G. The Call-for-Aid System shall meet all technical requirements for accessibility by individuals with disability under the Americans with Disability Act (ADA). These technical requirements are to be applied during the design and installation of the system. The Call-for-Aid shall fully comply with the following requirements:

1. ADA requirement 4.10.14 for providing emergency two-way communications between an elevator and a point outside the hoist way (the Kiosk).
2. ASME A17.1-2007. The highest operable part of the two-way communication system shall be a maximum of 48 inches from the floor.
3. ADA Standards 4.30. Raised symbol and lettering (Signage) located adjacent to the device.

H. The Call-for-Aid shall be equipped with a programmable autodial capability, allowing the system to dial up to two additional phone numbers if the primary number or Kiosk intercom station is busy, and/or a call is not answered by the Kiosk Station Manager. This roll-over capability is especially important, to make certain that no call originated by a patron goes unanswered.

I. The Call-for-Aid shall be provided with a full duplex speaker and microphone system to assure clear and continuous communication between the passenger and Kiosk (or remote telephone if rolled-over by the auto-dialer). It is essential that all information and instructions are transmitted and received by both parties of the conversation, including during the presence of high noise levels. The Call Stations shall be equipped with devices that shall allow adjustment of speaker volume and microphone sensitivity to overcome any background noise.

J. The Call-for-Aid shall include the following equipment, which shall be located in the passenger station Kiosk, except as noted:

1. Emergency Call-Stations complete with mounting plates and graphic panels located at designated locations.
2. Yellow strobe light and horn mounted on top of the Kiosk, and a networked relay module which will activate the strobe light and horn when a call is initiated from an Call-for-Aid call station on the platform, at the entrances and/or in an elevator. The strobe light and horn should not be activated when a Kiosk Attendant/Passenger intercom call is initiated.
3. Kiosk Master Station for communication with, and identification of, a calling station. The Kiosk Master Station shall provide the interface point between the Station Manager and the Integrated Intercommunication System. When a call station is activated, it shall result in the following actions at the Kiosk master station:
    a. Provide a digital display identifying the calling station, together with a call tone that is repeated until the call is acknowledged or cancelled.
    b. Once the call is answered by depressing the assigned button at the Kiosk master station, an audio path between the answerer and calling station shall be established.
    c. For programmable Call-for-Aid units provide on answer, at Kiosk, OCC roll, and/or EOC over, call identify of itself by using a prerecorded audio message.

K. The Master Station to be installed in the Kiosk shall operate much as a telephone so that it could be used to initiate calls, as well as receive and answer calls. The Master Station shall be programmed so that the Kiosk operator (manager) can identify the origination of the calling party.

L. The Call-stations shall be equipped with two visual indicators allowing hearing-impaired individuals to follow the progress of the emergency call. One indicator shall show that the call has been placed, and the other indicator shall show that the call has been answered. These LED indicators shall be large and bright (high intensity/wide angle type) so that a patron can see and identify the progress of the call during bright daylight.

M. The Call Stations shall be equipped with large red protruding Call Buttons (Approximately 11/4 inches in diameter) to allow easy patron identification and use.

Depending upon space availability, brail labels shall be installed either to the left, or below, the button.

N. Activation of an intercom call station shall function in the following sequence:

1. Pressing the “PUSH TO TALK” button on the call-station shall illuminate the red “call initiated” LED indicator and activate the strobe light in the nearest Kiosk. The strobe light should not be activated if the call-station located in the “paid” and/or “unpaid” areas of the Kiosk is used. When the call is answered, a green, “call acknowledged” LED indicator shall illuminate, and a full-duplex audio path shall be established with the master station. If the master station doesn’t answer within a preset time, the call shall be automatically routed either to the secondary Kiosk or to a pre-assigned OCC telephone number within the WMATA PBX system. If there is no answer at OCC, the call shall terminate after a preset time period adjustable from one to four minutes. If no answer at OCC, then the call should roll over to MOC, if no answer, then the call should roll over to a third party that WMATA will specify.

2. When the call is completed, and the answerer hangs up, or after a remotely-programmable period of time, whichever comes first, the emergency call station shall hang up, and the strobe shall be deactivated.

O. The Subcontractor shall be responsible for design of the interface of the Call-for-Aid and/or the VoIP telephone system. The Call-for-Aid system shall utilize and be supported by the VoIP call manager server of the VoIP telephone system. Call-for-Aid equipment shall be connected through the VoIP telephone system and the Ethernet LAN/WAN network.

1.02 RELATED DOCUMENTS

A. Section 27 065 10 – Communication Standard Specifications Equipment and Materials.

B. Section 27 05 26 – Grounding and Bonding for Communications Grounding Systems.

C. Section 27 05 14 – Communication Electrical Power Distribution.

D. Section 27 20 00 – Local Area Network / Wide Area Network (LAN/WAN)

E. Section 27 31 23 – Communications – VoIP Telephone System

F. Section 27 02 10 – Communications – KIOSK Systems

1.03 REFERENCES

A. The equipment shall meet ADA (Americans with Disability Act) requirements 4.10.14, when applicable, and installation shall comply with the current provisions of the following (applicable) standards and codes:

1. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).
2. National Electrical Code (NEC).
3. ASME A17.1 and A17.2.
4. Elevator Code of the local jurisdictions hereinafter referred to as the Code.
5. National Electrical Manufacturers' Association (NEMA).
6. Federal Transit Administration (FTA).
7. Underwriters' Laboratories, Inc. (UL).

B. These specifications are not to be construed as supplanting any code requirements.

C. In the event of a conflict between codes, regulations, these specifications or standards, the most stringent requirements as determined by the Contractor shall take precedence unless specifically addressed herein.

1.04 SUBMITTALS

A. See the Division 1 specifications of the Contract Documents for this section.

1.05 SUBCONTRACTOR'S TOTAL SYSTEM RESPONSIBILITY

A. The Subcontractor shall bear total system responsibility for all specified work, including specified or otherwise required additions and modifications to existing WMATA systems of any type. The Subcontractor's responsibility includes engineering services, design, fabrication, installation, testing, cut-over, commissioning, documentation, training and warranty. The Subcontractor has the responsibility to integrate the various necessary elements of work so that overall specification performance goals are met.

B. All Subcontractor-provided systems, equipment and services shall perform and be suitable for their intended purpose, in accordance with best commercial practices (as a minimum), and in compliance with all applicable specification requirements.

C. Subcontractor shall provide a complete and operable Integrated Intercom System meeting all performance specification requirements, notwithstanding any errors or omissions in Technical Specifications or Contract Drawings that would otherwise prevent such delivery shall be delivered. Clarification shall be requested from the Contractor if conflicts or errors are suspected.

D. The Subcontractor shall assume total responsibility for configuration of equipment, parts, interconnecting wiring, powering and surge protection devices, software, and other materials and services furnished. Systems provided by the Subcontractor that do not meet performance levels required by these Specifications shall be modified, at the Subcontractor's expense, until the performance levels specified in this Subcontract are achieved. Any modifications to approved system design shall be subject to prior approval.

E. The Subcontractor shall assume total responsibility for the correction of any degradation of the performance of existing systems or equipment, which results from the installation of any system or equipment interface required by these Specifications.

F. Although the Contractor retains rights to review the Subcontractor's system and component configuration compliance or noncompliance; the Subcontractor retains sufficient latitude to ensure compliance with all specified performance and availability requirements. The Subcontractor shall, therefore, present engineering data, technical documentation, test program and quality assurance program data, and product selections that will ensure compliance with the system technical specifications. In the event these submissions are not accepted, the Subcontractor shall resubmit with corrections, or resubmit completely revised documentation. The Subcontractor shall remain responsible for bearing any additional cost associated with charges necessary to affect compliance with all specified performance and availability standards, and all other specifications.

G. Contractor support will be limited to those items of work that are expressly stated to be "Contractor-Furnished" or "Contractor-Provided" in these Specifications or on the Contract Drawings. Certain other items of work may be performed by others. Such work is identified as "Work by others" or "Not in Contract (NIC)" means it is not part of this section, but may be part of the overall Subcontract. When (NIC) items are encountered, it is the Subcontractor's responsibility to coordinate with the Contractor to assure the system is fully integrated. All other items of work specified are the responsibility of the Subcontractor.

H. The Subcontract price shall provide full compensation for complete operational system, and all items and work furnished in compliance with these provisions. The Subcontractor shall remove rubbish and debris resulting from his work on a daily basis. Removal of debris and rubbish from the premises shall be coordinated with the WMATA Representative and/or the Station Manager when working in active passenger stations.

I. Quantities of equipment, material, and services specified in any of the following locations shall be furnished:
   1. Section entitled "...Equipment, Material, Spares..."
   2. Contract Drawings.
   3. Quantities determined from Contractor-approved final designs.
   4. This specification

J. Participate in Contractor Pre-final Inspections, Substantial Completion and Final Acceptance activities.

K. Clean the equipment and work site, secure the equipment, and remain responsible for prompt repair or replacement in case of loss or damage until acceptance by the Contractor is received. Furnish inventory services and demonstrate system or equipment operation in support of requests by the Contractor. Provide support and access so that

the Contractor Technicians, Mechanics and Inspectors can inspect and test any portion of the work during normal work hours.

L. New record As-Built/In-Service drawings (hard copies, and electronic media) to reflect the systems installed and/or modified under this Contract shall be furnished to the Contractor.

1.06 SYSTEM PERFORMANCE REQUIREMENTS

A. The following overall System performance requirements are designed to ensure that the system delivered under these Specifications, meets the performance requirements of WMATA.

1. Emergency call station Sound Pressure Level: The emergency call stations shall produce clear and continuous speech and call-waiting tones (to persons who are not significantly hearing impaired within the 300-Hz to 8,200-Hz audio range) to a distance of up to 36-inches or less, while moving to positions 40-degrees off-center in any quadrant. Interfering signals hum, or objectionable noise shall not be discernible to listeners during, or between, speech messages or tone generations.
2. Emergency Call Station Input Sensitivity: The emergency call station microphones shall be sensitive to (accept) any normal speaking voice from a distance of up to 20-inches, or less, from the front of the speaker, while moving to positions up to 30- degrees off center in any quadrant.
3. System Noise: Shall not exceed -45 dB below a 1-kHz test tone level when all system and equipment controls are operated to any possible combination of positions. Momentary switching transients may peak to -30dB below a 1-kHz test tone level for a duration that does not exceed 10-milliseconds. Note: Persons not significantly hearing-impaired within the 300-Hz to 3,600-Hz audio range are defined for the purpose of these performance specifications as males or females with hearing capabilities that are normal, or slightly impaired to the extent that their response to audio tones in the 300-Hz to 3,600-Hz frequency range is within -15 dB at all test frequencies, and averages within - 10 dB of "NORMAL" standard values for their classification (sex, age, etc.) as defined in ANSI Standards.

1.07 PRODUCT APPROVALS

A. Equipment to be installed under these Specifications (except for “Contractor-Furnished” items and miscellaneous hardware), shall be approved prior to purchase and installation. Exception: Product approval shall not be required prior to purchase and installation when the “Brand Name” or “Trade Name” products, as specified herein (without substitutions, option changes, deviations from specifications, etc.) are furnished. Record copies of such product data shall be furnished in lieu of product approval submitted (same schedule requirements, but not later than 30 days prior to installation or delivery to the Contractor, in any event).

B. Data for product approval shall be submitted with complete descriptions of the item, intended locations and functions, catalog cut-sheets, and technical literature and supporting data required to ascertain compliance with these Specifications. Approval or rejection shall not relieve the Subcontractor of any contractual responsibility.

C. Substitutions of items specified will only be acceptable if a Variance Request submitted by the Subcontractor has been approved.

1.08 QUALITY ASSURANCE

A. Codes, Regulations, Reference Standards and Specifications:

1. Codes and regulations of the Authority Having Jurisdictions.
2. 47 CFR 15, Subparts A and B.
3. UL 50.
4. NEMA AB 1 and NEMA KS 1.
5. ITU-T
6. ASME 17.1-2007 ADAAG
7. NFPA 130.5, 2010

B. Design and production tests: Perform the test and submit, certified test results, or provide certified test results on identical units. Furnish certified test reports showing test data and results as well as manufacturer's comments on tests.

C. Interchangeability: Refer to the Contract Documents. Furnish products of a manufacturer regularly engaged in the manufacture of applicable systems. In addition:

1. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable commercial off-the-shelf (COTS) products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices used.
2. With each system, subsystem and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions (outdoor systems are distinct from indoor systems).
3. Equipment shall be physically and plug compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA's facilities, insofar as possible. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Airports Authority to maintain interchangeability when competitive

products that do not require such devices are determined to be unavailable (applicable to COTS major equipment items only). Custom designed and fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, all necessary adapters and interface devices shall be provided with each item of equipment furnished, at no additional cost to the Airports Authority.

4. Equipment shall be software compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities.
5. Major items of equipment furnished shall be within the physical size and configuration limitations specified in provisions of this Subcontract. If such specifications are not included in the provisions, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use of comparable applications elsewhere in similar WMATA facilities.
6. Exception: Lighter weight and smaller sized more modern versions of equipment are sought by the Airports Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Airports Authority, in order to take advantage of significant technological improvements developed by industry.

D. Qualifications of Instructor for Operation and Maintenance Training:
1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance and trouble-shooting of the systems to be taught.
2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

1.09 SUBCONTRACTOR COORDINATION

A. Accomplishment of the work included in these Specifications may require the Subcontractor to coordinate with the Contractor representing the operating elements of WMATA and other subcontractors, to develop work schedules, to determine assignment of space and the availability of equipment, and to ascertain means of access to work areas.

B. Work schedules shall be coordinated with operating elements of WMATA through the Contractor, for assignments of space and access to operating facilities and for assignments of space and access to areas and rooms within the passenger stations, and the OCC, if applicable. All work performed at in-service Metrorail passenger stations shall be in accordance with WMATA Operating procedures, and at the discretion of the Contractor, and may require WMATA Escorts.

C. The Subcontractor shall coordinate with the Contractor to determine the availability and quantity of telephone lines roll-over or direct dial telephone numbers and call time-out details.

D. The Subcontractor shall (if applicable) coordinate with local fire authorities to ensure compliance with local fire codes, and to obtain all required permits and inspections. (Copies of all related documentation shall be furnished to the Contractor within 3 working days of receipt.)

E. The Subcontractor shall make every reasonable effort to resolve conflicts with other subcontractors and agencies. Those conflicts that cannot be resolved to the satisfaction of all parties concerned shall be referred to the Contractor for resolution.

F. Specific coordination with the elevator subcontractor will be required for the elevator intercom for elevator construction and certification. The Subcontractor shall coordinate design of wire and conduit plant, and connection of call stations, with the elevator subcontractor(s).

1.10 INITIAL SPARES

A. The Subcontractor shall develop a Recommended Spare Parts list for the system being provided in this contract and shall furnish the items in the quantities indicated in the Recommended Spare Parts list, subject to the agreement and approval of selected by the Authority.

B. All spare equipment and material shall be packed for warehouse storage. Like items (only) shall be grouped together and boxed as lots, as designated by the Contractor. Lots shall be marked as to item nomenclature, WMATA part number, contact number, specification reference, and end use (WMATA project identification data), as directed by the Contractor. Each individual item shall also be tagged with a WMATA part number, if a number is assigned by WMATA.

C. Spare equipment and materials shall be delivered for the newly-installed Intercom System to any of the various locations designated by the Contractor.

1.11 WARRANTY

A. Furnish a one (1) year service and maintenance program on Intercom equipment after final completion.

PART 2: PRODUCTS

2.01 CENTRAL EXCHANGE UNIT - EQUIPPED FOR 100 PLUS STATIONS

A. Manufacturer: Commend Model GE800 or approved equal

B. IP Intercom Server (Central Exchange Unit)

1. Central Exchange Unit (CEU) shall be installed in the passenger station Communications Room for control of the Integrated Intercommunications System equipment. Connect unit's power supply to an Uninterrupted Power Supply (UPS) backed source.

2. Configure the complete Central Exchange Unit so that it is capable of supporting up to 100 subscribers and include all subscriber cards required.

3. Install an analog telephone auto-dialer card to provide roll-over of calls to the WMATA Operations Control Center (OCC), Elevator Control Center (EOC), or other continuously staffed WMATA designated Control Center, when a call goes unanswered at the Kiosk. Connect this card to an analog telephone line.

4. Power supply: 24 VAC/40VA/16 subscribers or 24-35 VDC/40W/16 subscribers.

5. Relay outputs: maximum switching capacity 60W / 125VA, maximum switching current: 2 A, maximum switching voltage: 60 VDC/40 VAC.

2.02 MASTER STATION FOR KIOSK

A. Manufacturer: Commend Model EE320AS or approved equal

B. Kiosk - Master Station:

1. Integrated electret microphone and speaker for high fidelity audio.
2. Wall-mounted master station can be used as a handset or hands- free unit.
3. Telephone handset, with coiled cord.
4. Equipped with multifunction LED to indicate incoming calls.
5. Equipped with 6-character, alphanumeric (16-segment) display for identification of calling party.
6. Equipped with reinforced silicon keypad with additional function keys.
7. Modern DSP technology.
8. Frequency Range: 200-7000 Hz.
9. Color: Light grey

2.03 ELEVATOR MACHINE ROOM INTERCOM CALL STATION

A. Manufacturer: Command Model WS800FI or approved equal

B. Master Station for Elevator Machine Room:

1. Integrated microphone and speaker for high fidelity audio.
2. Surfaced mounted.
3. One-touch access to key Avaya features.
4. Equipped with red light indicating the station is in use.
5. Equipped with alphanumeric high-resolution backlit display for identification of calling party.
6. Includes a membrane keypad designed for harsh/or industrial environment.

7. VoIP Technology: IETF RFC 3261 (Session Initiation Protocol – SIP).
8. Power over LAN: IEEE802.3af.
9. Frequency Range: 200-16000 Hz.
10. Color: Light grey.

2.04 CALL STATIONS FOR ELEVATOR CARS/LANDINGS, KIOSKS AND PLATFORMS

A. Manufacturer: Commend Model ET508-DC Rev. B or approved equal

B. Elevator Cars/Landings, Kiosk and Platform Call Station:

1. Consists of a vandal resistant 11 AWG steel panel, custom painted to the Contractor required color.
2. Speaker, microphone and associated electronic circuitry are mounted behind the panel.
3. Includes a red mushroom-type call button.
4. Unit will include LED indications, one for call made, (red), and one for call answered, (green).
5. Relay contact.
6. VoIP Technology: IETF RFC 3261 (Session Initiation Protocol – SIP).
7. Power over LAN: IEEE 802.3af.

2.05 KIOSK PAID/UNPAID AND STATION GATED ENTRY- CALL STATIONS

A. Manufacturer: Commend Model ES931 A or approved equal

B. Kiosk Paid/Unpaid and Station Gated Entry - Call Stations:

1. Integrated weather resistant, vandal proof electret microphone and speaker for high fidelity audio.
2. Tamper and weather resistant construction.
3. Rugged, tamper resistant call button.
4. Faceplate Dimensions: 6-9/16" wide x 4-15/16" high.
5. Wiring: 4 twisted pair (Category 5 or higher).
6. Interface: RJ 45 (Static IP).
7. Power Requirement: 12-24VAC or 15-35VDC, 500mA or PoE (with PoE switch).
8. Frequency Range: 50-16,000 Hz.
9. Mounting: Standard 3-gang backbox. Backbox painted Benjamin Moore (Color 2) HC-170 Stonington Gray or other approved color.
10. LED for indication of conversations.
11. Protocol: lP-Protocol based on UDP/IP.

2.06 KIOSK CALL-ALERT STROBE LIGHT AND SONALERT UNIT

A. Manufacturers: Custom-built Kiosk Strobe and Sonalert Unit.

B. Strobe light and son-alert unit for Kiosk:

1. Unit is comprised of a weather resistant amber colored strobe light mounted to a short length of pipe for better visibility and a weather resistant outdoor speaker horn. Both the strobe light and speaker are mounted to a heavy duty box for installation on the roof of the Kiosk.
2. Power Requirements: .75 Amps @ 24VDC. (Power supply included).
3. Strobe Luminosity & Life: 1800 mcd @ 30MilliAmperes 100,000+ Hours.
4. Lens & Material: 5-3/4" diam., diffused lens optimum visibility and reliability for effective visual signaling.
5. Speaker: 15 Watt, 8 Ohm nominal.
6. Tone Frequency: Solid state generated square wave at approx. 800 Hz.
7. Tone Level Settings: Volume control, screw driver type located at rear of unit.
8. Functionality: Configured and installed as an integral unit of the Washington DC Metrorail System to provide features and functions per CALL-FOR-AID design in existing stations.
9. Two-piece screw terminal wiring means for ease of installation and maintenance.
10. Connect unit to ET901-D Ethernet IP converter & EB2E2A Option board in the Kiosk for activation control

2.07 PORTABLE MASTER STATION (MAINTENANCE-INTERCOM UNIT)

A. Manufacturer: Commend Model EE311AS or approved equal

B. Portable Master Station:

1. Integrated electret microphone and speaker for high fidelity audio.
2. Telephone handset with line cord for connection to elevator top-of-car jack.
3. Equipped with multifunction LED.
4. Equipped with 6-character, alphanumeric (16-segment) display for identification of calling party.
5. Equipped with reinforced silicon keypad with additional function keys.
6. Modern DSP technology.
7. Frequency Range: IP-Protocol based on UDP/IP
8. Color: Light grey.

2.08 IP-INTERCOM INTERFACE UNIT

A. Manufacturer: Commend Models ET901-A & ET901-D or approved equal

B. IP-Intercom Interface Unit:

1. Establishes the bridge between an Ethernet network with IP- protocol and any 2-wire digital or 4-wire analog intercom terminal.
2. utilizes the latest DSP technology which enables features such as Loudspeaker-/Microphone Surveillance and Audio Monitoring for any terminal connected.
3. Unit can be upgraded to handle additional inputs and outputs with an EB2E2A Option board.
4. Available as an open PC board unit; with a standard housing; or with a weatherproof housing.
5. Power: 24VAC +/- 5% or 28-35 VDC or PoE.
6 PoE (Power over Ethernet): IEEE 802.3af standard. Power connection of terminal device: Class 0 (0.44 W to 12.95 W).
7. Protocol: lP-Protocol based on UDP/IP.
8. Data Rate: 2 x 10/100 MBit/s (full/half duplex).

2.09 OPTION BOARD - (FOR KIOSK STROBE AND SONALERT UNIT ACTIVATION

A. Manufacturer: Commend Model EB2E2A or approved equal

B. Option Board:

1. Provides Intercom terminals with an expansion plug to be upgraded to handle additional inputs and outputs.
2. Unit can be integrated in the housing of the IP-Intercom Box ET 901.
3. Inputs: 2 inputs for floating contacts, max. 1 kOhm.
4. Outputs: 2 relay outputs (changeover contacts) rated 30V.

2.10 ELEVATOR MACHINE ROOM - IP CONVERTER ENCLOSURE

A. Manufacturer: Hoffman A30H20BLP or approved equal.

B. Interface Enclosure:

1. NEMA 4 enclosure for housing the IP converters associated with the elevator car units, elevator landing units and top-of-car jacks.

2. Provide backplate inside enclosure for mounting purposes.

3. The size of this enclosure may be adjusted to meet the needs of the devices being housed within it for each Elevator Machine Room but it shall be a NEMA 4 rated enclosure.

2.11 ELEVATOR MACHINE ROOM - PORTABLE MASTER STATION STORAGE ENCLOSURE

A. Manufacturer: Hoffman AHE12X8X4 w/T-Handle Latch or approved equal.

B. Interface Enclosure:

1. NEMA 1 enclosure to be installed in the Elevator Machine Room for housing the portable master station when not in use.

2.12 ELEVATOR TOP-OF-CAR JACK/MODULE

A. Manufacturer: Ortronics - OR-404IP22 Two-port industrial grade surface box, cover plate and watertight cable gaskets & plugs. Ortronics - OR-IPJ6 Category 6 industrial jack with protective cover cap or approved equals

B. Elevator Top-of-Car (TOC) jacks:

1. Provides a connection jack on top of each elevator car for the Portable Master Station Maintenance-Intercom Unit.
2. Assembly consists of a Category 6 telephone jack mounted in a weatherproof box with a weatherproof cover.

2.13 PLATFORM-EMERGENCY CALL STATION

A. Manufacturer: Commend Model EF963AM or approved equal

B. Platform-Emergency Call Station:

1. Provides a means for rail passengers located along the station platform to report emergencies to the Station Manager in the Kiosk.
2. The Emergency Call Station shall be located within signage, provided by others, that identifies the Call Station as an emergency reporting communications device.
3. Vandal-proof Stainless steel faceplate.
4. Integrated omnidirectional electret microphone and special membrane type loudspeaker for optimal sound quality.
5. Integrated amplifier class "D" 1.5 W.
6. Input: 3 inputs for floating contacts max. 1kOhm.
7. Output: 2 relay outputs.
8. Display: red operation LED.
9. Call button: red mushroom.
10. Frequency range: 200-7,000 Hz.
11. Power: external power supply 12-24 VAC or 15-35 VDC, 500mA, or PoE.
12. PoE: IEEE 802.3af standard. Power consumption of terminal device: Class 0 (0.44 W to 12.95 W).
13. Protocol: lP-Protocol based on UDP/IP.
14. Data rate: Autosense (10/100 MBit/s, full/half Duplex).
15. Cabling: Category 5 (minimum) required.
16. Surface mount using GUEF 63 backbox inside an EF 63G hood.

2.14 IP SUBSCRIBER CARD

A. Manufacturer: Commend Model G3-IP-4B or approved equal

B. IP Subscriber Card:

1. Cards install in Intercom Server for the connection of up to 8 Intercom terminals via Ethernet networks with IP-protocol.
2. Cards connect directly to a LAN/WAN without the need of media converters or multiplexers.
3. Available with 4 or 8 subscribers per card.
4. Provide with license upgrades L3-IP-8D and L3-IP-8B to allow connection of up to 8 subscribers per card.
5. Install proper number of cards with upgrade licenses to accommodate at least 100 subscribers (intercom units) per station.

2.15 MULTI-FUNCTION TELEPHONE INTERFACE CARD

A. Manufacturer: Commend Model G8-TEL4 or approved equal

B. Telephone Interface Card:

1. Integrated auto-dialer and telephone interface.
2. Powered from intercom server.
3. Telephone connection: RJ11.

2.16 CATEGORY-6 UNSHIELDED TWISTED PAIR (UTP) CABLE

A. Manufacturer: Berk-Tek LANMARK-1000 100 ohm, Category 6, 23 AWG, 4-pair shielded twisted pair (UTP) (or equal).

B. Cable to provide signal and power (POE) for ISS call stations and Master Stations:

1. 4-pair, unshielded twisted pair (UTP).
2. Meet TIA and ISO Category-6.
3. 23-AWG solid bare copper.
4. Insertion loss: 32.9 dB/100 meters at 250MHz.
5. Cable outside diameter: 0.220 inches.
6. Color: Blue (other color may be submitted for approval).
7. Primary insulation: FEP.
8. Jacket: Low-smoke PVC rated CMP (plenum).

2.17 TEST AND PROGRAMMING EQUIPMENT

A. Provide a minimum of one set of all equipment, adapters, software, manuals and external processors required to program, or reprogram, any portion or subsystem of the system.

PART 3 : EXECUTION

3.01 INSTALLATION

A. The new Call-for-Aid shall be installed and configured to provide the following Communications capabilities:

1. From the Kiosk Master Station to the “Paid” and “Unpaid” sides of the Kiosk.
2. From Elevator Car and Elevator Landing call stations to the Kiosk Master Stations.
3. From the passenger emergency Call Stations on the station platform(s) to the Kiosk Master Stations.
4. From the station entrance emergency Call Station to the Kiosk Master Stations.
5. From inside the gated entry points to the Entrance Pavilions or Pedestrian Bridges that end at a gated entry
6. The Area Refuge and Dispersal Areas.
6. From top of elevator cars utilizing a waterproof jack as a connection means for a portable master stations maintenance intercom unit
7. Roll-over capabilities to other Kiosk Call-Stations or to external facilities as pre-programmed into the system, if a Kiosk Master Station doesn’t respond to the incoming call.
8. The Subcontractor shall coordinate and work with the Contractor and WMATA to develop a call routing plan designating numbers to be dialed and roll-over functions in the event that calls are unanswered at specific locations.

B. **KIOSK**

1. Install a dedicated AC circuit for the Intercom System, originating from the Communications Room Power Distribution Panel supplied by the station UPS (Uninterrupted Power Source).
2. Install the Passenger/Kiosk Attendant call-stations in the “paid” and “unpaid” areas of the Kiosk(s), and wire to the 24-Port Category-6 Patch Panel for connection to the Kiosk Data Switch.
3. Install the Intercom Master Station in the Kiosk(s) and wire to the 24-Port Category-6 Patch Panel for connection to the Kiosk Data Switch.
4. Install the Kiosk-mounted strobe light in view of one of the Kiosk windows, and wire to the Networked Relay Module for connection to the Kiosk Data Switch.
5. The Call-for-Aid equipment and the VoIP call manager server shall be programmed to provide the necessary features and functions for all Call Stations (Elevator Car(s), Elevator Landings, Kiosk Intercom Call Stations and Master Station, and the Platform Stations). The Call-for-Aid equipment and the VoIP call manager server shall be completely programmed for all the correct Call- Station addresses and user-defined message, and roll-over functions where applicable.

C. Platform Call-Stations

1. Install two Emergency Call Stations on each platform of the passenger stations. The Emergency Call Stations shall be surface-mounted on selected columns along the platform areas via mounting brackets or back-plates. The call station shall be clearly visible to the general public.
2. Install the Emergency Call Stations on the columns via the mounting brackets or back-plates. Verify, at each designated column, that the installation of the Emergency Call Station does not interfere with signage graphics. Conflicts between column graphics and the installation of the Emergency Call Station shall be referred to the Contractor for resolution.
3. To prevent tampering with the Emergency Call Station, removal of the phone from the associated mounting bracket shall require special tools.
4. Install two Category-6 cables from each Emergency Call Station to the nearest Category-6 Patch Panel in the Kiosk or in the Communications Equipment Room. One cable will be connected to the Data Switch. The other cable shall be terminated and marked as spare.

D. Elevator Call-Stations

1. Install an Emergency Call Station in each elevator car and elevator landing location. The Subcontractor shall interface with the elevator subcontractor concerning the mounting method, and location of the call station inside the elevator car, and its' wiring connection to the Kiosk via the LAN/WAN outlet in the associated Elevator Machine Room. The Subcontractor shall submit drawing details of the proposed mounting method and location for approval prior to installation.

2. Install a Master Call-Station in each Elevator Machine Room and provide Category-6 wiring connection to the nearest Data Switch in the Kiosk or in the Communications Equipment Room.

3. Provide one portable Master Station for maintenance purposes locate in the storage enclosure of each Elevator Machine Room. The portable Master Station will be provided with a line cord for connection to the top-of-car jack for use during elevator maintenance

E. Communications Equipment Room

1. Install a Call-for-Aid Central Exchange Unit (CEU GE 800) in the Communications Equipment Room at each passenger station and connect it to the Comm. Room LAN Data Switch for function control of all associated Call-for-Aid call stations.
2. Program the CEU and LAN Data Switches to provide all the system functions required by this specification.

3. Install and properly program a telephone auto-dialer card within the CEU in the Communications Equipment Room to allow calls that go unanswered by the Kiosk Call-for-Aid Master Station to be routed to WMATA Operations Control Center (OCC) or other continuously manned Control Center as designated by WMATA for handling of these calls. Connect the telephone auto-dialer to an analog phone line via the G450 unit in the Comm. Room.

F. Entrance Pavilions and Pedestrian Bridges Gated Entry Points

1. Install Call-for-Aid Call Station on the interior side of each Entrance Pavilion or Pedestrian Bridge gated entry point to provide emergency communications for persons that may become trapped at these gated entry points during hours when the passenger station is closed.

2. Provide Category-6 wiring from the Call-for-Aid Call Station to the nearest designated Patch Panel and LAN Data Switch.

   a. Install one Emergency Call Stations immediately next to each main entrance into the passenger stations. The Emergency Call Stations shall be surface-mounted via mounting brackets or back-plates.

   b. Verify that the installation of the Emergency Call Station does not interfere with signage and does not impede passenger entrance.

   c. To prevent tampering with the Emergency Call Station, removal of the phone from the associated mounting bracket shall require special tools.

3.02 FIELD QUALITY CONTROL

A. The new Intercom System shall be installed and fully tested with current calibrated equipment, under the supervision of trained manufacturers' representative. The system shall be demonstrated to perform all functions as specified.

3.03 SYSTEM TESTINGS

1. The completely-installed Intercom System shall be fully tested (on a station-by-station basis) with the Contractor-Approved test procedures. The Contractor reserves the right to witness system acceptance testing of the supplied Call-for-Aid at each location.
2. All test equipment, instruments, tools and labor required to conduct the tests shall be made available by the installing Subcontractor. All test equipment shall have a current calibrated test data tag.

3.04 CLOSEOUT ACTIVITIES

A. Demonstrate operation and maintenance of Products to WMATA's personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA's personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

F. Demonstrate system operation.

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component

END OF SECTION

SECTION 16732

FIRE ALARM, DETECTION AND NOTIFICATION SYSTEM

PART 1 – GENERAL

1.01 SUMMARY

A. The work covered by this Section of the Specification shall include all labor, equipment, materials and services to furnish and install a complete fire alarm system.

1. Fire Alarm Control Panel.
2. Remote Annunciator.
3. Manual pull stations.
4. Smoke detectors.
5. Heat detectors.
6. Fire Alarm System Interface Controls- Proprietary supervising station, magnetic door/card access release override, and air handling system.
7. Notification appliances.
8. Air handling systems shutdown control.
9. Magnetic door holder release.
10. Fire Suppression Supervision- Wet pipe, dry pipe, deluge valve, pre-action System, kitchen hood, clean agent and Halon system monitoring.

B. Related Sections:

1. Section 08331 – Overhead Coiling Doors.
2. Section 08710 – Finish Hardware.
3. Section 13905 – Fire Protection, Suppression and Alarm.
4. Section 14200 – Hydraulic Elevators.
5. Section 14240 – Traction Elevators.
6. Section 14300 – Heavy-Duty Escalator.
7. Section 16120 – Wire, Cable and Busways.
8. Section 16130 – Raceways, Boxes and Cabinets.
9. Section 16705 – Communications Standard Specifications – Equipment & Material.
10. Section 16706 – Communications Systems Submittals & Services.
11. Section 16707 – Communications Systems Quality Assurance & Testing.
12. Section 16710 – Communications Grounding.Section 16715 – Communications Electrical Power Distribution.
13. Section 16733 – Communications – Kiosk Systems.

14. Section 16925 – ATC – Data Transmission System.

1.02 REFERENCES

A. The system and all components shall be approved by insurance provider for use in fire protection systems and compliant with all insurance provider guidelines. If insurance provider approval is not available, insurance representatives must be consulted to ensure system is acceptable and components must at least be listed by Underwriters Laboratories, Inc. for use in fire protective signaling systems.

B. The installation shall comply with:

1. State and Local Building and Fire Codes.

2. Americans with Disabilities Act (ADA).

3. NFPA 70 – National Electrical Code.

4. NFPA 72 – National Fire Alarm and Signaling Code.

5. Local and State Authorities Having Jurisdiction.

6. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

7. NFPA 70 - National Electrical Code

8. NFPA 101 - Life Safety Code

1.03 SUBMITTALS

A. Provide a list of all types of equipment and components provided. This shall be incorporated as part of a Table of Contents, which shall also indicate the manufacturer's part number, the description of the part, and the part number of the manufacturer's product data sheet on which the information can be found. See Division 1 for specific details about submissions.

B. Provide a Sequence of Operation matrix. The sequence of operation shall be building specific, and shall provide individual sequences for every type of alarm, supervisory or trouble condition which may occur as part of normal or off-normal system use.

C. Provide manufacturer's original printed product data, catalog cuts and description of any special installation procedures. Photocopied and/or illegible product data sheets shall not be acceptable. All product datasheets shall be highlighted or stamped with arrows to indicate the specific components being submitted for approval.

D. Provide manufacturer's installation instruction manual for specified system.

E. Provide samples of various items when requested.

F. Provide copy of state License to perform such work.

G. Provide copies of NICET Level IV Fire Alarm certifications for a minimum of two (2) technicians assigned to this project also responsible for Fire Alarm Control Panel (FACP) programming.

H. Provide shop drawings as follows:

1. Coversheet with project name, address and drawing index.

2. General notes drawing with peripheral device back-box size information, part numbers, device mounting height information, and the names, addresses, point of contact, and telephone numbers of all contact project team members.

3. Building specific device riser diagram, which individually depicts all control panels, annunciators, addressable devices, and notification appliances. Include a specific, proposed point descriptor above each addressable device. Include a specific discrete point address that shall correspond to address depicted on the device layout floor plans. Drawing shall provide wire specifications, and wire tags shown on all conductors depicted on the riser diagram. All circuits shall have designations that shall correspond with those required on the control panel and floor plan drawings. End-of-line resistors (and values) shall be depicted.

4. Control panel termination drawing(s). Include internal component placement and all internal and field termination points. Drawing shall provide a detail indicating where conduit penetrations shall be made, so as to avoid conflicts with internally mounted batteries. For each additional data gathering panel, a separate control panel drawing shall be provided, which clearly indicates the designation, service and location of the control enclosure. End-of-line resistors (and values) shall be depicted.

5. Building specific device wiring diagram drawing(s) shall be provided which depict all system components, and their respective field wiring termination points. Wire type, gauge, and jacket shall also be indicated. When an addressable module is used in multiple configurations for monitoring or controlling various types of equipment, different device typical diagrams shall be provided. End-of-line resistors (and values) shall be depicted.

6. See section 3.05 CLOSEOUT ACTIVITIES for other documents relating to this section.

I. Battery calculations shall be provided on a per power supply/charger basis. These calculations shall clearly indicate

1. The quantity of devices

2. The device part numbers

3. The supervisory current draw

4. The alarm current draw

5. Totals for all categories, and the calculated battery requirements (which reflect a 20% DEGRADE, for 24 hour supervisory, 5 minute alarm operation).

6. Battery calculations shall also reflect all control panel components, remote annunciator, and auxiliary relay current draws.

J. Scale drawing sets shall be submitted along with the submittal book. These drawings shall be 22” x 34” and of a sufficient resolution to be completely legible when reduced to 11” x 17” size.

K. Written proof of proper disposal by the installing contractor shall be required prior to release of outstanding retainage.

L. Turnover of all software database hard/soft copies to WMATA prior to the end of the one (1) year warranty period (or period as amended earlier in this specification). This shall include all possible programming software logs, exported project files, hard copies of all device maps, the revision number of the version of programming utility used, and all required passwords. This information shall be provided to WMATA on a flash drive.

1.04 QUALITY ASSURANCE

A. Qualifications: Company specializing in installation of work in this Section with minimum of three years documented experience, approved by manufacturer.

B. System Standards:

1. NFPA 72.

2. CEC, Article 760.

C. Design criteria:

1. Comply with all system standards.

2. Meet all requirements of fire authorities having jurisdictions.

3. The Building Electronics contractor shall provide complete fire detection and alarm system design, wiring diagrams, interphase wiring diagrams, and operational details.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt, dust and any other contaminants.

B. Project staging may be provided at stakeholders' convenience. A staging area is not guaranteed.

1.06 RELATED WORK

A. The fire alarm and detection system provides controls to and/or interfaces with the following systems and equipment:

1. Ventilation fans.

2. Fire suppression systems.

3. Elevators and escalators.

4. Data Transmission Systems (DTS).

5. Automatic Fare Collection (AFC).

6. Automatic public address.

7. Fire standpipe systems.

8. Clean agent systems.

9. Combustible gas detection.

10. Carbon monoxide detection.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers capable of meeting the system requirements of Part 2 of this specification.

B. New fire alarm equipment shall be compatible with the existing WMATA fire alarm equipment. New equipment shall be able to provide two-way command and control communication between an EST Fireworks® head end and all protected premise fire alarm control panels and field devices.

2.02 EQUIPMENT

A. Fire Alarm Control Panel (FACP)

1. The fire alarm control panel(s) shall be an Edwards EST-3 or equivalent. System devices (notification appliances, pull stations, smoke and heat detectors, etc.) shall be compatible with one another. All components will be labeled "FM approved" for the use of fire alarm systems in this area of the United States of America.

2. Fire alarm control panel cabinet shall be 3-CAB series or equivalent. Cabinet shall be manufactured from #14 AWG cold rolled steel with a gray baked enamel finish. Operating controls shall be located behind a locked door with a viewing window.

3. Fire alarm control panel enclosures shall have engraved labels indicating, “FIRE ALARM SYSTEM”, and the areas of the building served by that panel.

4. All control modules shall be labeled, and all zone locations shall be identified.

5. Conventional fire alarm panel supporting 1/3/5/10 initiating device circuits and 1 through 4 notification appliance, Class B circuits as required in the space. If the panel is not a slave provide Digital Alarm Communicator Transmitter (DACT) for off premises communication.

6. The system shall store all basic system functionality and job specific data in non-volatile memory. All site specific and operating data shall survive a complete power failure intact. Passwords shall protect any changes to system operations.

7. The system shall have built-in automatic system programming to automatically address and map all system devices attached to the main controller. A minimum default single stage alarm system operation shall be supported with alarm silence, event silence, drill, lamp test, and reset common controls.

8. The system shall support distributed processor intelligent detectors with the following operational attributes: integral multiple differential sensors, automatic device mapping, electronic addressing, environmental compensation, pre-alarm, dirty detector identification, automatic day/night sensitivity adjustment, normal/alarm LEDs, relay bases, sounder bases and isolator bases.

9. The system shall use full digital communications to supervise all addressable loop devices for placement, *correct location*, and operation. It shall allow swapping of “same type” devices without the need of addressing and impose the “location” parameters on replacement device. It shall initiate and maintain a trouble if a device is added to a loop and clear the trouble when the new device is mapped and defined into the system.

10. The fire alarm panel shall provide integral security system interfaces.

B. User Interface

1. The display module shall be of membrane style construction with a 24 line by 40-character (960 total characters) Liquid Crystal Display (LCD). The LCD shall use super-twist technology and backlighting for high contrast visual clarity and a colored grey/black and white display.

    1.1 In the normal mode the LCD shall display the time, a customer facility name, and the number of history events.

    1.2 In the alarm mode the LCD shall display the total number of events and the type of event. The LCD shall display the first event of the highest priority as well as the previous seven (7) alarm events “hands free” in chronological order so that the arriving firefighter may track the fire progression. The LCD shall reserve 42 characters of display space for each user custom message by addressable device.

2. There shall be common control keys and visual indicators for reset, alarm silence, panel silence and drill.

    2.1 Provide four pairs of display control keys for selection of event display by type (alarm, supervisory, monitor and trouble) and forward/backward scrolling through event listings.

2.2 The operation of these keys shall be integrated with the related common control indicators to flash the indicators when un-displayed events are available for display and turn on steady when all events have been displayed.

3. Provide system function keys for status, reports, enable, disable, activate, restore, program and test. The module shall have a numeric keypad, zero through nine with delete and enter keys.

4. Provide field programmable 12 switch 12 LEDs control display module.

   As an alternate if the above cannot be provided, provide UL 864, 9th edition PC graphics display.

C. Software

1. Windows-based System Utility with Program Version Reporting to document any and all changes made during system start-up or system commissioning shall be used to maintain site specific programming. Time and Date Stamps of all modifications made to the program must be included to allow full retention of all previous program version data. Software will be Edwards EST-3 or equivalent and capable of coordination with EST fireworks head end. It shall support programming of any input point to any output point. The system shall support the use of Bar Code readers to assist custom programming functions. It shall allow authorized customization of fundamental system operations using initiating events to start actions, timers, sequences and logical algorithms. The system program shall meet the requirements of this project, current codes and standards, and satisfy the local Authority Having Jurisdiction.

D. Digital Alarm Communicator Transmitter (DACT)

1. The FACP shall have a DACT module to transmit alarm, supervisory and trouble signals to a central monitoring or proprietary supervising station.

2. The DACT shall support dual telephone lines, Contact I.D. communications, and configured for dual tone multi-frequency (DTMF) or pulse modes.

3. It shall be possible to delay AC power failure reports, auto test call, and be site programmable.

4. The dialer shall be capable of transmitting every individual alarm condition to the central station or proprietary supervising station.

E. Network Communications Card

1. A network communication card shall be provided for each building to allow building to building, peer to peer networking.

F. Fiber Optics Communications Interface

1. Fiber optics communications interface shall be provided for buildings, where available, to allow building to building networking in a Class A configuration.

G. System Controllers

1. The main controller shall be supervised, site programmable, and of modular design supporting at least 125 detectors and 125 remote modules per addressable Signaling Line Circuit (SLC).

2. The controllers shall support up to 10 SLC's per panel for a total system capacity of 2,500 intelligent addressable points.

3. The system shall be designed with peer-to-peer networking capability for enhanced survivability, with support for up to 64 nodes, each with up to 2,500 points and an overall capacity of 160,000 points.

4. The cabinets shall be steel, with a red finish.

5. The main controller module shall control and monitor all local or remote peripherals. It shall support at least a large 960 character LCD, power supply, remote LCD and zone display annunciators, printers, and support standard communication interface protocol devices such as color computer annunciators and color graphic displays. If configured as a network, each system shall display every point in the system and shall support up to 64 remote LCD display annunciators. Remote LCD annunciators shall also display every point in the system and be sized with the same number of characters as in the main FACP display.

6. Each controller shall contain a communication card which contains two RS232 ports. A computer for programming locally and a printer shall be provided and connected to the RS232 ports, a RS232 printer/programming port for programming locally via PC. When operational, each controller shall support a printer through the RS232 port and be capable of message routing.

7. Single stage operations shall be provided.

8. The system shall have a listed Detector Sensitivity test feature, which will be a function of the smoke detectors and performed automatically every 4 hours.

9. The system shall support 100% of all remote devices in alarm and provide support for a 100% compliment of detector isolator bases.

H. Power Supplies

1. Provide a power supply with power input of 120 VAC, 3.0A, 50/60 Hz and power output of Internal DC 24 Vdc @ 7.0A Max, Auxiliary DC Two 24 Vdc @ 3.5A Max. The battery charger shall be included in the power supply.

2. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection.

3. The power supply shall provide internal power and 24VDC at 7.0A continuous for notification appliance circuits.

4. The power supply shall be capable of providing 7.0A to output circuits for a maximum period of 100 milliseconds. All outputs shall be power limited.

5. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 5 minutes.

I. Auxiliary Power Supplies

1. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection.

2. The power supply shall provide internal power and 24VDC at 7.0A continuous for notification appliance circuits.

3. The power supply shall be capable of providing 7.0A to output circuits for a maximum period of 100 milliseconds. All outputs shall be power limited.

4. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 5 minutes.

J. Annunciators

1. The graphic remote annunciators shall be mounted in stand-alone enclosures or integrated into the network panels. The annunciator graphical diagram shall be 1/16 inch per foot scale minimum and operating on normal 24 Vdc. All annunciator switches shall be system input points and shall be capable of controlling any system output or function. The graphic annunciator shall be UL and ULC listed. The graphic shall be back-lit using high intensity LEDs. The unit shall be semi-flush or surface mounted. The main graphic door shall be tamper resistant and equipped with a key lock. It shall be possible to update the graphic image in the field without replacing the entire graphic.

2. Network alpha-numeric annunciators shall be located throughout the facility as indicated on the design drawings. The system shall have the capacity to support 64 network annunciators or network panel nodes. Each annunciator shall contain a supervised, back lit LCD with a minimum of 8 lines with 21 characters per line. Where required, the annunciator shall include additional zonal annunciation and manual control without additional enclosures.

3. The annunciator shall support full ability to serve as the operating interface to the system and shall include the following features:

    a. Matched appearance with other system displays.

    b. Each LCD on each node (cabinet) in the system shall be configurable to show the status of any or all of the following functions anywhere in the system: Alarm, Supervisory, Trouble and Monitor.

4. Each annunciator shall be capable of supporting custom messages as well as system event annunciation. It shall be possible to filter unwanted annunciation of trouble, alarm or supervisory functions by point or by geographic area.

K. Intelligent Devices

1. Each remote device shall have a microprocessor with non-volatile memory to support its functionality and serviceability. Each device shall store as required for its functionality the device serial number, device address, device type, personality code, date of manufacture, hours in use, time and date of last alarm, amount of environmental compensation left/used, last maintenance date, job/project number, current detector sensitivity values, diagnostic information (trouble codes) and algorithms required to process sensor data and perform communications with the loop controller. Each device shall be capable of electronic addressing, either automatically or application programmed assigned, to support physical/electrical mapping and supervision by location. Setting a device's address by physical means shall not be necessary.

L. Intelligent Detectors

1. The system intelligent detectors shall be capable of full digital communications using both broadcast and polling protocol. Each detector shall be capable of performing independent fire detection algorithms. The fire detection algorithm shall measure sensor signal dimensions, time patterns and combine different fire parameters to increase reliability and distinguish real fire conditions from unwanted deceptive nuisance alarms. Signal patterns that are not typical of fires shall be eliminated by digital filters. Devices not capable of combining different fire parameters or employing digital filters shall not be acceptable.

2. Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detector head. Distributed intelligence shall improve response time by decreasing the data flow between detector and analog loop controller. Maximum total analog loop response time for detectors changing state shall be 0.5 seconds.

3. Each detector shall have a separate means of displaying communication and alarm status. A green LED shall flash to confirm communication with the analog loop controller. A red LED shall flash to display alarm status.

4. The detector shall be capable of identifying up to 32 diagnostic codes. This information shall be available for system maintenance. The diagnostic code shall be stored at the detector. Each smoke detector shall be capable of transmitting pre-alarm and alarm signals in addition to the normal, trouble and need cleaning information. It shall be possible to program control panel activity to each level.

5. Each smoke detector may be individually programmed to operate at any one of five (5) sensitivity settings. Each detector microprocessor shall contain an environmental compensation algorithm that identifies and sets ambient "Environmental Thresholds" approximately six times an hour. The microprocessor shall continually monitor the environmental impact of temperature, humidity, other contaminates as well as detector aging. The process shall employ digital compensation to adapt the detector to both 24-hour long term and 4-hour short-term environmental changes. The microprocessor shall monitor the environmental compensation value and alert the system operator when the detector approaches 80% and 100% of the allowable environmental compensation value. Differential sensing algorithms shall maintain a constant differential between selected detector sensitivity and the "learned" base line sensitivity. The base line sensitivity information shall be updated and permanently stored at the detector approximately once every hour.

6. The intelligent analog detectors shall be suitable for mounting on a variety of orientation/condition-specific detector mounting bases.

M. Fixed Temperature/Rate of Rise Detector

1. Heat detectors shall have a low mass thermistor heat sensor and operate at a fixed temperature and at a temperature rate-of-rise. It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm. The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. The intelligent heat detector shall have a nominal fixed temperature alarm point rating of 135^0F and a rate-of-rise alarm point of 15^0F per minute. The heat detector shall be rated for ceiling installation at a minimum of 70 ft centers and be suitable for wall mount applications.

N. Photoelectric Smoke Detector

1. Analog photoelectric detectors shall utilize a light scattering type photoelectric smoke sensor to sense changes in air samples from its surroundings. The integral microprocessor shall dynamically examine values from the sensor and initiate an alarm based on the analysis of data. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC or other equivalent program/service tool. The photo detector shall be rated for ceiling installation at a minimum of 30 ft centers and be suitable for wall mount applications. The photoelectric smoke detector shall be suitable for direct insertion into air ducts up to 3 ft high and 3 ft wide with air velocities up to 4,000 ft/min. without requiring specific duct detector housings or supply tubes. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The photo detector shall be suitable for operation in the following environment: Temperature: 32^0F to 120^0F, Humidity: 0-93% RH, non-condensing, Elevation: no limit.

O. Multi-sensor Detector

1. Provide intelligent multi-sensor smoke detectors. The multi-sensor analog detector shall use a light scattering type photoelectric smoke sensor, a unipolar ionization smoke sensor and an

ambient temperature sensor to sense changes in air samples from its surroundings. The integral microprocessor shall employ time based algorithms to dynamically examine values from the three sensors simultaneously and initiate an alarm based on that data. The multi-sensor detector shall be capable of adapting to ambient environmental conditions. The temperature sensor shall self-adjust to the ambient temperature of the surrounding air and input an alarm when there is a change of 65^0F in ambient temperature. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, age and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC. Separately mounted photoelectric detectors, ionization detectors and heat detectors in the same location are not acceptable alternatives. The multi-sensor smoke detector shall be rated for ceiling installation at a minimum of 30 ft centers and suitable for wall mount applications.

P. Detector Mounting Base

1. Detector mounting bases shall be suitable for mounting on North American 1-gang, 3½" or 4" octagon box and 4" square box. The base shall contain no electronics, support all detector types and have the following minimum requirements: Removal of the respective detector shall not affect communications with other detectors, Terminal connections shall be made on the room side of the base; bases that must be removed to gain access to the terminals shall not be acceptable. The base shall be capable of supporting one (1) remote alarm LED Indicator. Provide remote LED alarm indicators where shown on the plans.

Q. Duct Detector Housing

1. Provide low profile intelligent addressable duct smoke detector as indicated on the project plans. Provide for variations in duct air velocity between 100 and 4,000 feet per minute and include a wide sensitivity range of .79 to 2.46%/ft. Obscuration. Include one shut down relay rated 2.0 amps @ 30 Vdc and also include slave high contact relays if required. Provide an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet. The addressable duct housing shall be suitable for extreme environments, including a temperature range of –20 to 158 degrees F and offer a harsh environment gasket option. Provide remote alarm LED Indicators and/or remote test station as indicated on the project plans.

R. Intelligent Modules

1. It shall be possible to address each module without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The personality of multifunction modules shall be programmable at site to suit conditions and may be changed at any time using a code downloaded from the Analog Loop Controller. Modules requiring EPROM, PROM, ROM changes or DIP switch and/or jumper changes shall not be acceptable. The modules shall have a minimum of 2 diagnostic LEDs mounted behind a finished cover plate. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The module shall be capable of storing up to 24 diagnostic codes which can be retrieved for troubleshooting assistance. Input and output circuit wiring shall be supervised for open and ground faults. The module shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non- condensing.

S. Single Input Module

1. Provide intelligent single input modules. The Single Input Module shall provide one (1) supervised Class B input circuit capable of a minimum of 4 "personalities", each with a distinct operation. The module shall be suitable for mounting on North American 2 ½"deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The single input module shall support the following circuit types: Normally- Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-

Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches.

T. Dual Input Module

1. Provide intelligent dual input modules. The Dual Input Module shall provide two (2) supervised Class B input circuits each capable of a minimum of 4 "personalities", each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers. The dual input module shall support the following circuit types: Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches).

U. Monitor Module

1. Provide intelligent monitor modules. The Monitor Module shall be factory set to support one (1) supervised Class B Normally-Open Active Non-Latching Monitor circuit. The monitor module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1½" deep 4" square boxes with 1-gang covers.

V. Universal I/O

1. Provide motherboards that provide mounting and wire terminations for modules. The motherboard shall support up to six modules. Locations: Communication Equipment Room, and Ancillary locations.

W. Waterflow/Tamper Module

1. Provide intelligent waterflow/tamper modules. The Waterflow/Tamper Module shall be factory set to support two (2) supervised Class B input circuits. Channel A shall support a Normally-Open Alarm Delayed Latching Waterflow Switch circuit. Channel B shall support a Normally-Open Active Latching Tamper Switch. The waterflow/tamper module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

X. Single Input Signal Module

1. Provide intelligent single input signal modules. The Single Input (Single Riser Select) Signal Module shall provide one (1) supervised Class B output circuit capable of a minimum of 2 "personalities", each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" deep 2-gang boxes and 1 ½" deep 4" square boxes with 2-gang covers. The single input signal module shall support the following operations: Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A).

Y. Control Relay Module

1. Provide intelligent control relay modules. The Control Relay Module shall provide one form "R" dry relay contact rated at 2 amps @ 24 Vdc to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware. The control relay module shall be suitable for mounting on 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

Z. Conventional Manual Pull Stations

1. It shall be double action model with single pole contact used for pre-signal or general alarm initiation. The model shall have terminals for field connection of wire. The manual stations

shall be provided with a key lock matching the FACP. The manual pull station shall not be provided with a glass break operation. Surface mount the manual pull station unless flush mount is possible. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non- condensing. Provide accessories as required for the installation.

AA. Intelligent Manual Pull Stations

1. It shall be possible to address each fire alarm pull station without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The manual stations shall have a minimum of 2 diagnostic LEDs mounted on their integral, factory assembled single or two stage input module. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The station shall be capable of storing up to 24 diagnostic codes that can be retrieved for troubleshooting assistance. Input circuit wiring shall be supervised for open and ground faults. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non-condensing.

BB. Manual Pull Station

1. Provide intelligent double action, single stage fire alarm stations. The fire alarm station shall be of metal construction with an internal toggle switch. Provide a locked test feature. Finish the station in red with silver “PULL IN CASE OF FIRE” English lettering. The manual station shall be suitable for mounting on North American 2 ½” deep 1-gang boxes and 1½” deep 4” square boxes with 1-gang covers.

CC. Notification Appliances

1. All appliances shall be FM Approved for Fire Protective Service. All strobe appliances or combination appliances with strobes shall be capable of providing the “Equivalent Facilitation” which is allowed under the Americans with Disabilities Act accessibly guidelines (ADA (AG)), and shall be UL 1971. All appliances shall be of the same manufacturer as the Fire Alarm Control Panel (NO EXCEPTIONS) specified to insure absolute compatibility between the appliances and the control panels, and to insure that the application of the appliances are done in accordance with the single manufacturers’ instructions. Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from THE CONTROL PANEL MANUFACTURER clearly stating that the control equipment (as submitted) is 100% compatible with the submitted Notification Appliances.

DD. Strobes

1. Provide low profile wall mounted strobes at the locations shown on the drawings. Strobes shall provide synchronized flash outputs. Strobe output shall be field selectable as indicated on the drawings in one of the following intensity levels; 15/75, 15cd, 30cd, 75cd or 110cd*. Low profile strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field. Provide weatherproof type and associated components when strobe is located outside or in areas requiring weather proofing.

EE. Temporal Horn/Strobes

1. Provide low profile wall mount horn/strobes at the locations shown on the drawings. The horn/strobe shall provide an audible output of 84.4 dBA at 10 ft at the high setting and for smaller room size locations (as indicated on the plans) a low dB setting (field selectable) of 79.4 dB at 10 ft. when measured in reverberation room per UL-464. Strobes shall provide synchronized flash outputs. The strobe output shall be as indicated on the drawings in one of the following field selectable intensity levels*; 15/75, 15cd, 30cd, 75cd & 110cd devices. The horn shall have a selectable steady or synchronized temporal 3-3-3 output. Low profile

horn/strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

FF. Temporal Horn

1. Provide low profile wall mount horn at the locations shown on the drawings. The horn shall provide an audible output of 84.4 dBA at 10 ft at the high setting and for smaller room size locations (as indicated on the plans) a low dB setting (field selectable) of 79.4 dB at 10 ft. when measured in reverberation room per UL-464. The horn shall have a selectable steady or synchronized temporal 3-3-3 output. Low profile horn shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

GG. Speaker/Strobe

1. Provide low profile wall mount speaker/strobes at the locations shown on the drawings. The strobe output shall be as indicated on the drawings in one of the following field selectable intensity levels; 15cd, 30cd, 75cd & 110cd devices. Speakers shall operate between ¼ Watt and 2 Watts and shall provide an audible output between 80 dBA and 89 dBA.

HH. Speaker

1. Provide low profile wall mount speakers at the locations shown on the drawings. Speakers shall operate between ¼ Watt to 2 Watts and shall provide an audible output between 80 dBA and 89 dBA.

II. Multi-Voltage Control Relays

1. Provide remote control relays connected to supervised ancillary circuits for control of fans, dampers, door releases, etc. Relay contact ratings shall be DPDT and rated for 10 amperes at 115 Vac. A single relay may be energized from a voltage source of 24 Vdc, 24 Vac, 115 Vac, or 230 Vac. A red LED shall indicate the relay is energized. A metal enclosure shall be provided.

JJ. Electromagnetic Door Holders

1. Electromagnetic door holders submitted for use must have written proof of their compatibility for the purposes intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purposes intended.

2. Wall mounted, provide flush, semi-flush or surface wall mounted electromagnetic door holder/releases rated at 24 Vac/dc. Finish shall be brushed zinc.

KK. Surge Suppressor

1. Surge suppressors shall be multi-stage, hardwired base, field replaceable, with multiple voltage settings. 2 pairs shall be protected per module. UL497B listed with 10AWG max screw terminals. 0-75 service voltage, 6.6-108V list through voltage.

LL. Manual Pull Station Guards

1. Manual pull stations shall be provided with guards as required on the plans. They shall be surface or flush mounting, as required for each individual device.

MM. Voice Evacuation

1. The audio system must provide simultaneous page, alert, and evacuation signals. Systems that cause signaling devices to go silent while performing signaling functions will not be acceptable. The system must provide operation to 25Vrms or 70.7Vrms speakers. The system

must provide as a minimum the following paging common controls and indicators: Ready to page LED, VU display of paging output level, single switch function for paging to all — Alert zones, Evacuation zones, and areas not programmed for signaling. The system must provide high quality analog to digital conversion of paging sources. Digital transmission of paging must be provided between system nodes. The analog sources must be sampled and converted to digital with a sampling rate no less than 9600 samples per second. It must be possible to transmit signal sources (Alert, Alarm, Page, etc.) together over a single pair of wires between nodes. System amplifiers must be distributed zoned type. Centrally banked systems are not acceptable. An integral circuit for operating traditional Network Access Control (NAC) devices must be provided with each system amplifier. The circuit must carry a minimum rating of 3.5 Amps for operating 24 VDC signals. The system shall provide fully integrated fire fighters' telephone system that shall provide 2-way communication between the fire alarm control panel and any fire fighters' telephone station. The system shall include an alphanumeric user display and controls. When a telephone is activated, a call-in buzzer shall sound, and the location of the phone shall be shown on the alphanumeric display. The display shall be capable of bilingual operation, displaying English, Dutch, Finnish, French, German, Italian, Portuguese or Spanish messages. The incoming call shall be selected by activating a single button. All subsequent telephone call locations shall be displayed in full text. The system shall display all incoming calls, all connected phone(s) on the alphanumeric display. The system shall be configured so that page messages may be issued from any firefighter's telephone connected to the system, as directed by the emergency operator.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Shop drawings must be submitted and approved prior to execution of any installation or demolition activity.

B. Circuiting

1. Addressable analog signaling line circuit, initiating device circuit and notification appliance circuit loops shall be Class B. Conventional signaling line circuit, initiating device circuit and notification appliance circuit loops shall be Class B. Network communication and annunciator communication loops shall be Class A. Tee tapping is not permitted for any circuit.

2. Device loading shall not exceed 80% of loop capacity for each addressable or conventional analog loop to accommodate the installation of future devices.

3. Provide intelligent input modules to supervise Class B zone wiring where required to interface conventional initiating devices.

4. Sprinkler systems shall be supervised as follows:

a. Provide one (1) supervisory module for each sprinkler valve supervisory switch.

b. Provide one (1) dual input addressable module where water flow and tamper switches exist at the same location.

c. Provide one (1) additional single input addressable module where odd numbers of devices exist at a single location.

5. Notification appliance circuits:

a. Audible Signals: Provide sufficient spare capacity to assure that an increase of 20% of the audible devices can be supported without the need for additional components (power supplies, signal circuit modules, batteries, etc.).

b. Visual Signals: Provide sufficient spare capacity to assure that an increase of 20% of the visual devices can be supported without the need for additional components (power supplies, signal circuit modules, batteries, etc.).

6. Each of the following types of remote equipment associated with the fire alarm system shall be provided with a form 'C' control relay contact as follows, unless otherwise noted on the drawings:

   a. HVAC Fan Systems: Provide one (1) shutdown control relay contact for each HVAC fan system.

   b. HVAC Supply Fans: Provide one (1) shutdown control relay contact for each HVAC supply fan.

   c. HVAC Return Fans: Provide one (1) shutdown control relay contact for each HVAC return fan.

7. Provide a dedicated 24VDC circuit to feed all auxiliary relays required for inductive loads. Circuits shall be supervised via an end-of-line relay and addressable input module. Auxiliary relays shall not derive their power from the starter or load being controlled.

8. Each control or data gathering panel shall have a dedicated 20 Amp, 120VAC feed. This feed shall come from an emergency circuit breaker panel where available, and shall have a locked circuit breaker. Earth grounds shall also terminate to the same circuit breaker panel from each respective control panel.

9. The system shall have a CPU "watchdog" circuit to initiate trouble should the CPU fail.

10. All low voltage wiring terminated to the fire alarm system shall be plenum rated with no exceptions and no less than No. 18 AWG in size, and solid copper.

11. All line voltage (120VAC) wiring shall be no less than No. 12 AWG in size, and solid copper. This shall include all system grounding. FACP must have a dedicated 20 Amp circuit marked back at the power panel no exceptions.

12. All wiring shall be color-coded throughout, to National Electrical Code standards.

13. Power-limited/non-power-limited NEC wiring standards shall be observed.

14. All junction box covers shall be painted federal safety red and labeled FIRE ALARM SYSTEM ONLY in black letters.

15. Fire alarm system wiring shall not co-mingle with any other system wiring in the facility. Conduits shall not be shared under any circumstance. Only when fire alarm wiring enters the enclosure of a monitored or controlled system will co-habitation be permitted (i.e. at fan starters or elevator controllers).

16. Auxiliary relays shall be appropriately labeled to indicate "FIRE ALARM SYSTEM" and their specific function (i.e. FAN S-1 SHUTDOWN).

17. All fire alarm wiring shall be continuous and without splices. Terminations shall only occur at fire alarm devices or control panel enclosures under terminal screws. All other splicing methods are specifically disallowed (i.e. plastic wire nuts).

18. All fire alarm wiring shall be installed in conduit. See Specification Section 16120.

19. All fire alarm wiring shall be sleeved when passing through any wall, using conduit sleeves (1"min.) with bushings, and fire stopped in accordance with Code.

20. The fire alarm system shall be arranged to receive power from one three wire 120 Vac, 20 A supply. All low voltage operation shall be provided from the fire alarm control panel.

21. End of Line Resistors shall be furnished as required for mounting as directed by the manufacturer. Devices containing end-of-line resistors shall be appropriately labeled. Devices should be labeled so removal of the device is not required to identify the EOL device.

22. New door holders shall derive their 24VAC/VDC power from a separate power supply housed in a dedicated, metal enclosure. The power supply shall have a 120VAC feed, and is to be centrally located to serve door holders on a per floor or area basis. All existing door holders shall be connected to new FACP. E.C. shall extend all existing wiring in order to make this work.

23. All WMATA protected premises report to two proprietary supervising station locations. The supervising station locations are located at the Jackson Graham Building and at the Carmen Turner Facility.

C. Fire Alarm System Sequence of Operation

1. The system shall identify any off normal condition and log each condition into the system database as an event.

   a. The system shall automatically display on the control panel Liquid Crystal Display the first event of the highest priority by type. The priorities and types shall be alarm, supervisory, trouble and monitor.

   b. The system shall have a Queue operation, and shall not require event acknowledgement by the system operator. The system shall have a labeled color coded indicator for each type of event; alarm shall be red, supervisory shall be yellow, trouble shall be yellow, monitor shall be yellow. When an unseen event exists for a given type, the indicator shall be lit.

   c. For each event, the display shall include the current time, the total number of events, the type of event, the time the event occurred and up to a 42 character custom user description.

   d. The user shall be able to review each event by scrolling keys (up-down) for each event type.

   e. New alarm, supervisory or trouble events shall sound an audible signal at the control panel; the operator shall be able to silence this audible signal.

2. Operation of any alarm initiating device shall automatically:

   a. Update the control/display as described in this Section.

   b. Sound all audible appliances in a Temporal-3 pattern. All audible appliances shall be synchronized with each other when two or more horns can be heard. Audible devices shall have the ability to be silenced.

   c. Activate all strobe appliances throughout the facility. All strobe appliances shall be synchronized with each other in any location with two or more devices in a common field of view. Visual devices shall be non-silenced unless the system is successfully reset.

   d. Operate control relay contacts to shutdown HVAC units in accordance with IMC requirements.

e. Operate control relay contacts to return all elevators that serve the floor of alarm initiation to the ground floor. If the alarm originates from the ground floor, operate control circuits contacts to return all elevators to the floor above or to a level as directed by the local fire department.

f. Operate control relay contacts to release all magnetically held smoke doors throughout the building.

g. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain activated until the alarm condition is reset to normal.

h. Transmit an alarm condition to central station/local fire department and/or proprietary supervising station (as required by the AHJ/WMATA).

3. Elevator smoke and heat detector sequences shall comply with ANSI A17.1 Safety Code for Elevators and Escalators requirements and local code requirements for main/alternate floor recalls, and shunt trip activations.

4. Activation of a sprinkler supervisory initiating device shall:

   a. Update the control/display as described in this Section.

   b. Transmit a supervisory condition to central station/local fire department and/or proprietary supervising station (as required by the AHJ/WMATA).

   c. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.

5. All fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or disarrangement of system wiring and shorts across alarm signaling wiring shall automatically:

   a. Update the control/display as described in this Section.

   b. Transmit a trouble condition, via the integral central station communicator, to the central station/local fire department and proprietary supervising station (as required by the AHJ).

   c. Visually and audibly annunciate a general trouble condition on the remote annunciator panels. The visual indication shall remain on until the trouble condition is repaired.

6. Purge/Smoke Control

   a. Smoke control panels shall be UUKL listed specifically for smoke control operation to allow the smoke purge control to be housed in the FACP cabinet. The smoke control switches shall be located behind a locked glass door.

   b. Where required, each floor shall have a dedicated switch for fan shutdown via a listed addressable control module. Each damper shall also be monitored at the panel for open/close position via control module. This module shall illuminate the associated green LED when the damper is open and the red LED when the damper is closed. The dampers shall be interlocked with the fans to prevent the fan from activating while the damper is closed.

7. All panel modules shall be supervised for placement and return trouble if damaged or removed.

8. All WMATA protected premises report to two proprietary supervising station locations, and to the WMATA contracted third party monitoring location. The supervising station locations are located at the Jackson Graham Building and at the Carmen Turner Facility.

D. Device Mounting

1. The entire system shall be installed with aesthetics in mind as approved by WMATA. All control panels and remote annunciators installed in public spaces shall be semi-flush mounted with no exposed conduit or cable trays unless approved by WMATA.

2. All manual pull stations shall be mounted 48 inches above the finished floor, as measured to the handle.

3. Wall-mounted appliances shall be mounted such that the entire lens is not less than 80 in. and not greater than 96 in. above the finished floor. Where low ceiling heights do not permit mounting at a minimum of 80 in., appliances shall be mounted within 6 in. of the ceiling. All audiovisual devices shall have lexan covers in all areas.

4. No area smoke detectors shall be mounted within 36 inches of any HVAC supply, return air register or lighting fixture.

5. No area smoke or heat detector shall be mounted within 12 inches of any wall. All detectors shall be installed in strict accordance with NFPA 72 guidelines for such devices.

6. All addressable modules shall be mounted within 36 inches of the monitored or controlled point of termination. This shall include, but is not necessarily limited to, fan shutdown, elevator recall, shunt trip, sprinkler status points, or door release. Label all addressable modules as to their function.

7. All fire alarm devices shall be accessible for periodic maintenance. Should a device location indicated on the Contract Drawings not meet this requirement, it shall be the responsibility of the installing contractor to bring it, in writing, to the attention of WMATA. Failure to bring such issues to the attention of WMATA shall be the exclusive liability of the installing Contractor.

3.02 CONSTRUCTION

A. System cable and devices shall be installed and inspected based on Fire Marshal approved drawings. Original contract drawings are for bidding purposes only. The entire system shall be installed in accordance with approved manufacturer's wiring diagram. The contractor shall furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for the complete installation. All wiring shall be of the type recommended by the manufacturer, approved by the local Fire Department and specified herein.

B. All penetration of floor slabs and firewalls shall be sleeved (1" conduit minimum) fire stopped in accordance with all local fire codes.

C. The existing fire alarm system shall remain in operation until such time that approval has been granted for its removal.

D. After acceptance of the new building fire alarm system, the installing Contractor shall be responsible for the removal of entire existing fire alarm system components and controls, upon approval of the AHJ and WMATA. WMATA reserves the right to retain any existing fire alarm system components, upon their request. All existing fire alarm system components requiring special handling for disposal (due to radioactivity) shall be the responsibility of the installing contractor.

E. Prior to commencement and after completion of work notify Authorities Having Jurisdiction

3.03 FIELD/SITE QUALITY CONTROL

A. The system shall be installed and fully tested under the supervision of a trained manufacturer's representative. The system shall be demonstrated to perform all of the function as specified.

B. The installing contractor or fire alarm equipment vendor shall have no less than two (2) NICET Level III fire alarm technicians dedicated to this project.

C. The Installing Contractor and the Fire Alarm System Vendor shall, upon the request of the Consulting Engineer or WMATA attend any and all project meetings for the purpose of accurately determining progress.

D. It shall be the responsibility of the installing contractor to assure that construction debris does not adversely affect any sensing devices installed as part of this project. Should it be deemed necessary by the WMATA construction manager, the installing contractor shall be responsible for the cleaning of all smoke detectors prior to final acceptance.

3.04 SYSTEM STARTUP

A. Tests

1. The fire alarm system vendor shall test the system in accordance with the manufacturer's requirements and NFPA 72. The vendor shall provide final acceptance test reports to WMATA for review and approval prior to final acceptance.

2. Each individual system operation on a circuit by circuit basis shall be tested for its complete operation in accordance with NFPA 72 (2010ed.), Table 14.4.2.2 (see appropriate section from other editions). The procedure for testing the entire fire alarm system shall be set forth with the consent of the code enforcement official, the Engineer and the manufacturer.

3. Provide a NFPA 72 System Record of Completion Form for each part of the fire alarm system as required.

3.05 CLOSEOUT ACTIVITIES

A. Documentation and Training

1. The contractor shall compile and provide to WMATA a complete manual on the completed system to include site specific operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams and a manufacturer's suggested spare parts list. An operational Video, on DVD media, shall also be included.

2. The Contractor shall provide the onsite services of a manufacturer's trained representative for two (2) separate calendar days for a period of eight (8) hours per day to instruct the WMATA's designated personnel on the operation and maintenance of the entire system.

3. Submit letter of approval for installation before requesting acceptance of system.

B. As-built Drawings

1. Revise existing drawings to incorporate contract work.

2. Point-to-point depiction of all device wiring on the device layout floor plans.

3. Full size, as-built drawings.

4. All drawings should be readable and printable in 11 x 17.

5. Provide electronic copies in AutoCAD and PDF.

6. Provide one copy inside PVC pipe next to FACP.

3.06 MAINTENANCE

A. Provide a coded one-man walk test feature. Allow audible or silent testing. Signal alarms and troubles during test. Ensure receipt of alarms and programmed operations for alarms from areas not under test.

B. Provide internal system diagnostics and maintenance user interface controls to display/report the power, communication, and general status of specific panel components, detectors, and modules.

C. Provide loop controller diagnostics to identify common alarm, trouble, ground fault, NFPA 72 Class A fault, and map faults. Map faults include wire changes, device type changes by location, device additions/deletions and conventional open, short, and ground conditions. Ground faults on the circuit wiring of remote module shall be identified by device address.

D. Allow the user to display/report the condition of addressable analog detectors. Include device address, device type, percent obscuration, and maintenance indicator. The maintenance indicator shall provide the user with a measure of contamination of a device upon which cleaning decisions can confidently be made.

E. Allow the user to report history for alarm, supervisory, monitor, trouble, smoke verification, watchdog, and restore activity. Include Facility Name, Licensee, Project Program Compilation date, Compiler Version, Project Revision Number, and the time and date of the History Report.

F. Allow the user to disable/enable devices, zones, actions, timers and sequences. Protect the disable function with a password.

G. Allow the user to activate/restore outputs, actions, sequences, and simulate detector smoke levels.

H. Allow the service user to enter time and date, reconfigure an external port for download programming, initiate auto programming and change passwords. Protect these functions with a password.

I. WMATA shall retain complete rights and ownership to all software running in the system. The fire alarm equipment vendor shall provide useable hard and soft copies of the software database to WMATA at the end of the warranty period. The database provided shall be useable by any authorized and certified distributor of the product line, and shall include all applicable passwords necessary for total and unrestricted use and modification of the database.

END OF SECTION

SECTION 16733

COMMUNICATIONS - KIOSK SYSTEMS

PART 1 GENERAL

1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

A. The purpose of the Kiosk System is to provide the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to provide data signals to fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).

B. At least one kiosk is located in each passenger station of the Washington Metropolitan Area Transit Authority (WMATA) Rail Rapid Transit System. It is the focal point of activity at each passenger station. At large passenger stations, each operational level may contain more than one kiosk. Where more than one kiosk is located on a single level, one kiosk is designated as the "Major Kiosk." All other kiosks are designated "Minor Kiosks." In those stations where a single kiosk exists, it is considered to be the "Major Kiosk."

C. Facilities are to be provided in each kiosk for the station manager to monitor and control passenger station systems. The contractor shall provide a complete "Kiosk Facility" which shall include kiosk cabinets, system interface panels, cables, cable termination facilities, loudspeakers, wiring and all hardware needed to complete the installation of Station Monitor/Control Systems in the kiosk. The requirements for the individual monitor/control panels and systems, to be installed in the kiosk under this contract, are included in the respective System Specification Sections.

D. The contractor shall provide Cabinet Bays #1 through #6 in the Kiosk(s) included in this contract, as indicated on the contract drawings. Kiosk Cabinet Bay #7 will be furnished and installed by other trades.

E. The contractor shall provide a Cable Termination Rack in Cabinet Bay # 3 of the kiosk(s) covered by this contract. The kiosk Cable Termination Rack shall consist of seven Terminal Strips and a Line Terminal Block. Terminal Strips shall be equally spaced on the Termination Rack. Each Terminal Strip within the kiosk Cable Termination Rack shall consist of sixty (60) individual terminals. The kiosk Cable Termination Rack shall be provided in the kiosk(s) to terminate all cables and wires that are to be installed into the kiosk(s) under this contract, with the following exceptions:

1. Coaxial video cables.
2. Automatic Public Address Announcement System cables.
3. Passenger Emergency Reporting System cables.
4. Kiosk Multiline Telephone Cable Connections.

F. The coaxial cables from the station Communications Equipment Room are terminated on the Coaxial Cable Termination Panel in Bay # 3. The coaxial cables from the kiosk video equipment shall also be terminated on the Coaxial Cable Termination Panel. The Automatic Public Address Announcement System cables and the Passenger Emergency Reporting System cables are terminated on the Emergency Communications Kiosk Terminal Panel.

G. The Contractor shall provide an Emergency Communications Kiosk Terminal Panel in Bay # 3 of the cabinetry in the kiosk(s) included in this contract. The Emergency

Communications Kiosk Terminal Panel shall be the interface point for cables from the station Communications Equipment Room to the kiosk control panels, for the Automatic Public Address Announcement System and the Passenger Emergency Reporting System. The Emergency Communications Kiosk Terminal Panel shall consist of three terminal blocks mounted on a 16-gauge steel plate. Two blocks shall have a minimum of 23 miniature terminals, and the other block shall have a minimum of 20 miniature terminals. Details on the layout, mounting and lettering of the Emergency Communications Kiosk Terminal Panel are included on the contract drawings.

H. The contractor shall provide a 24-Vdc Power Supply in the Public Address System Equipment Rack located in the station(s) Communications Equipment Room, and shall interconnect it to the kiosk Cable Termination Rack. The 24-Vdc Power Supply will be used to power the Escalator Display Panel in the kiosk(s).

I. The contractor shall engineer, draw, print and deliver to the Authority, Kiosk Data Files for the passenger station(s) under this Contract. The Kiosk Data Files shall be designed to be a convenient source of information on the layout of the following systems:

1. Passenger Station Telephones.
2. Right-of-Way and Ancillary Building Telephones.
3. Passenger Station Fire Zones.
4. Ancillary Building Fire Zones.
5. Passenger Station Intrusion Zones.
6. Ancillary Building Intrusion Zones.
7. Escalators.
8. Closed Circuit Television System.
9. Passenger Emergency Reporting System.

J. Contractor shall also provide laminated Fire and Intrusion Zone tables for the passenger station(s).

K. The Escalator Display Panel provides four status indicators and one identification indicator for each of up to 16 escalators. The following indicators are provided for each escalator:

1. Direction of Travel - "UP" or "DOWN."
2. Automatic Operation - "AUTO OPER."
3. Out of Service -"OUT SERV."
4. Escalator Identification - "ESC XX" where "XX" is the number of the escalator.

L. The Escalator Display Panel also includes a momentary, non-illuminating, pushbutton switch to permit a lamp test of all indicators on the panel.

M. Kiosk Monitor/Controls provide the station manager with a means to effectively manage passenger station activities. The operation of the monitor/control panels and systems, to be installed in the kiosk under this contract (except the Escalator Control Panel described in this Section), is described in the individual system specifications.

1.02 SECTION INCLUDES

A. Kiosk Cabinet Bays #1 through #6C in the Kiosk(s).

B. 24-Vdc Power Supply.

C. Escalator Display Panel.

D. Kiosk Data File.

E. Kiosk Cable Termination Rack.

1.03 UNIT PRICES

A. Unit Prices include all required conduits and fittings, junction boxes, feeder wires, branch circuit wiring, and cabling to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.04 RELATED SECTIONS

A. Section 14200 - Hydraulic Elevators.

B. Section 14240 - Traction Elevators.

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C. Section 14300 - Heavy-Duty Escalator.

D. Section 16705 - Communications Standard Specifications - Equipment & Material.

E. Section 16706 - Communications System Submittals & Services..

F. Section 16707 - Communications Systems Quality Assurance & Testing

G. Section 16710 - Communications Grounding.

H. Section 16715 - Communications Electrical Power Distribution.

I. Section 16721 - Communications - Telephone System

J. Section 16727 - Communications - Passenger Emergency Reporting System.

K. Section 16771 - Communications - Carrier Transmission System

L. Section 16776 - Communications - Fiber Optic System..

M. Section 16731 - Communications - Fire Alarm System..

N. Section 16820 - Communications - Public Address System..

O. Section 16821 - Communications - Automatic Public Address Announcement System.

P. Section 16851 - Communications - Passenger Station Closed-Circuit Television System.

1.05 REFERENCES

A. National Electric Code (NEC).

1.06 SYSTEM DESCRIPTION

A. Description: The Kiosk System provides the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to provide data signals to fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).

B. Capacity:
   1. The Contractor shall furnish and install a 24-Vdc Power Supply for the kiosk that is sufficient to power all the 24-Vac equipment located in the kiosk, plus 50% spare capacity.
   2. The Contractor shall furnish and install kiosk Cabinet Bays #1 through #6C in the kiosk(s).
   3. The Contractor shall install the Escalator Display Panel(s) furnished by other trades.
   4. The Contractor shall author, publish and furnish one set of Kiosk Data Files for each kiosk in each passenger station, and 12 additional sets of Kiosk Data Files to the Authority for each passenger station.
   5. The Contractor shall furnish and install a Kiosk Cable Termination Rack in each kiosk.
   6. The Contractor shall furnish and install an Emergency Communications Kiosk Terminal Panel in each kiosk.
   7. The contractor shall install an Elevator Control Panel (provided under Section 14200 - Hydraulic Elevators or Section 14240 - Traction Elevators) in the kiosk.

C. The Kiosk Cable Termination Rack consists of seven Terminal Strips and a Line Terminal Block in Cabinet Bay 6B. Each Terminal Strip within the Kiosk Cable Termination Rack consists of sixty (60) individual terminals. The Kiosk Cable Termination Rack terminates all cables and wires that are to be installed into the kiosk(s) in this contract, with the following exceptions:
   1. Coaxial video cables.
   2. Automatic Public Address Announcement System cables.
   3. Passenger Emergency Reporting System cables.
   4. Kiosk Multi-line Telephone Cable Connections.

D. The coaxial cables from the station Communications Equipment Room are terminated on the Coaxial Cable Termination Panel in Bay 6B. The coaxial cables from the kiosk video equipment are also terminated on the Coaxial Cable Termination Panel. The Automatic Public Address Announcement System cables and the Passenger Emergency Reporting System cables are terminated on the Emergency Communications Kiosk Terminal Panel.

E. The Emergency Communications Kiosk Terminal Panel in Bay 6B is the interface point for cables from the station Communications Equipment Room to the Kiosk control panels, for the Automatic Public Address Announcement System and the Passenger Emergency Reporting System.

F. A 24-Vdc Power Supply in the Public Address System Equipment Rack located in the station(s) Communications Equipment Room, and interconnects to the kiosk Cable Termination Rack to provide power to the Escalator Display Panel in the kiosk(s).

G. The Kiosk Data Files provide a convenient source of information on the layout of the following systems:
   1. Passenger Station Telephones.
   2. Right-of-Way and Ancillary Building Telephones.
   3. Passenger Station Fire Zones.
   4. Ancillary Building Fire Zones.
   5. Passenger Station Intrusion Zones.
   6. Ancillary Building Intrusion Zones.
   7. Escalators.
   8. Closed Circuit Television System.
   9. Passenger Emergency Reporting System.

H. The Escalator Display Panel provides four status indicators and one identification indicator for each of up to 16 escalators. The following indicators are provided for each escalator:
   1. Direction of Travel - "UP" or "DOWN."
   2. Automatic Operation - "AUTO OPER."
   3. Out of Service -"OUT SERV."
   4. Escalator Identification - "ESC XX" where "XX" is the number of the escalator.

1.07 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram and mechanical layout.

C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

E. Submitted to the Engineer for approval prior to reproduction, lamination and assembly a draft copy of each Kiosk Data File for the passenger station(s).

F. Furnish a complete set of Mylar reproducible drawings for the Kiosk Data File of the passenger station(s), and electronic copies (in AutoCAD, latest release format) on diskette and compact disk.

1.08 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

C. Installer: Service facilities within 50 miles of Project.

1.09 MAINTENANCE SERVICE

A. Furnish service and maintenance of Kiosk Systems until Final Completion.

PART 2 - PRODUCTS

2.01 TERMINALS

A. Manufacturers:
   1. Weidmuller, Model No. SAKC4 Complete with Channel Mounting System (or approved equal).

B. Ratings:
   1. Terminal Type: Modular Micro Terminal with Screw Clamp Connection.
   2. Wire size accommodated: #22 thru #12-AWG.
   3. Rated Current: 27-Amps.

4. Rated Voltage: 300-Vdc.
5. Center-to-Center Spacing: 6-mm.

2.02 LINE TERMINAL BLOCK

A. Manufacturers:
1. Siecor, Model No. A0293268 (or approved equal).

B. Ratings:
1. Terminal Type: Wire Wrapping Terminals.
2. Terminal Configuration: 4 rows x 26 clips.
3. Mounting Base: Adjustable from 7-inches to 9-inches.

2.03 24-VDC POWER SUPPLY

A. Manufacturers:
1. Acopian, Model No. 24PH30 (or approved equal).

B. Ratings:
1. Input Voltage: 105-125 Vac, 60 Hz, Single Phase.
2. Output Voltage: 24-Vdc ± .5-Vdc (adjustable).
3. Output Current (minimum): 30-Amps @ 40°C. 23-Amps @ 55°C.
4. Ambient Operating Temperature: -20 to +55° C.
5. Regulation (line/load): ± .05%.
6. Size: Not greater than 3 vertical rack units (19-inch rack).
7. Standard RETMA 19-inch cabinet rack mount.

2.04 KIOSK CABINET BAY ASSEMBLY

A. Manufacturers:
1. Custom made.

B. Ratings:
1. Frame Material: 16-Gauge Galvanized Steel.
2. Exposed Metal Finish: Metro Bronze Color 20040 (Federal Standard 595B).
3. Desk Tops: 1-inch Marine Plywood (MARINE AA EXT-APA).
4. Hardware: Cadmium Plated.
5. Desk-Top Laminate: Formica Grade 10 (or approved equal).
6. Desk-Top Laminate Color: Neutral White #918.

2.05 KIOSK DATA FILE

A. Manufacturers:
1. Custom made.

B. Description: Each Kiosk Data File shall consist of eight or more 11" x 17" drawings.

C. Prepared Kiosk Data File drawings to document each of the following subjects:
1. Telephones (passenger station) - A cross-reference of telephone numbers and telephone locations within a passenger station.
2. Telephones (Right-of-Way and Ancillary Facilities) - A cross-reference, by telephone numbers and locations, of the telephones along the right-of-way and in ancillary facilities associated with a passenger station.

3. Fire Zones (Passenger Station) - A cross-reference of the designated fire zones, room numbers and room descriptions for all areas within a passenger station, including ancillary facilities within the passenger station limits.
4. Fire Zones (Ancillary Facilities) - A cross-reference of the designated fire zones in remote ancillary facilities associated with a passenger station.
5. Intrusion Zones (passenger station) - A cross-reference of the designated intrusion zones, room numbers and room descriptions for all areas of a passenger station, including ancillary facilities within the passenger station limits.
6. Intrusion Zones (Ancillary Facilities) - A cross-reference of the designated intrusion zones in remote ancillary facilities associated with a passenger station.
7. Escalators - A cross-reference of assigned escalator numbers and escalator locations within a passenger station.
8. CCTV - A cross-reference of television monitor assignments and arrangements, and television camera designations, locations and areas of coverage for all television cameras and television monitors within a passenger station.
9. Passenger Emergency Reporting System - A layout of platform(s) showing locations and designations of call stations.

D. Ratings:
1. Seal Kiosk Data File drawings in a protective plastic laminate.
2. Each Kiosk Data File set shall be in loose-leaf booklet form.
3. Covers: 11" x 17", minimum of 60-pound punched paper with holes reinforced with plastic, cloth or metal, and sealed in a protective plastic laminate.

2.06 EMERGENCY COMMUNICATIONS KIOSK TERMINAL PANEL

A. Manufacturers:
1. Custom made.

B. Description: The Emergency Communications Kiosk Terminal Panel consist of three terminal blocks mounted on a 16-gauge steel plate and have the following characteristics:
1. Two of the terminal blocks shall each have a minimum of 23 miniature terminals.
2. The other terminal block shall have a minimum of 20 miniature terminals.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Kiosk cabinet bay assembly installation
1. Install the assembled kiosk cabinetry in the kiosk of the passenger station(s). Cabinet assembly installation shall be as follows: Bays #1, #2A, 2B, 2C and #3 as a single unit; Bays #4, #5, and #6A, 6B, and 6C as a single unit. Secured to the floor of the kiosk. Kiosk cabinets may be secured to the kiosk sides with the approval of the Engineer; however, the securing hardware shall not carry any vertical load. Hardware installed in the kiosk sides shall only be used to prevent horizontal movement.

B. Kiosk cable termination rack installation
1. Install a Kiosk Cable Termination Rack in Kiosk Cabinet Bay 6B of the kiosk. Install structure elements in the Kiosk Cabinet Bay 6B to accommodate the Terminal Strips and the Line Terminal Block of the Kiosk Cable Termination Rack.

C. Emergency communications kiosk terminal panel

1. Install an Emergency Communications Kiosk Terminal Panel in Kiosk Cabinet Bay 6B of the kiosk, as indicated on the contract drawings. Installation shall not interfere with the Cable Termination Rack Terminal Strips. Secure Cables to the Emergency Communications Kiosk Terminal Panel to the panel to prevent interference with the Kiosk Cable Termination Rack wiring and cabling.

D. Escalator display panel

1. Install an Escalator Display Panel in Cabinet Bay 3 of the Kiosk. install the required wiring harness(es) between the panel and the Kiosk Cable Termination Rack in Bay 6B, and make all necessary connections and cross-connections. Install one 9-conductor, 18-AWG, shielded cable for each escalator associated with the passenger station(s) between the Kiosk Cable Termination Rack in Bay 6B of the Kiosk and the Escalator Terminal Box in the escalator wellways. Terminate the cables in the kiosk and at the escalators and make all necessary connections and cross-connections.

E. Standard time cable

1. Install a six-pair individually shielded "Standard Time" cable between the TC/COMM Interface Cabinet in the station Communications Equipment Room and the kiosk. Terminate the pairs at the TC/COMM Interface Cabinet and at the kiosk Cable Termination Rack in Bay 6B of the kiosk cabinets and make all necessary connections and cross-connections.

F. Kiosk 24-vdc power facility

1. Install the 24-Vdc Power Supply in the Public Address System Equipment Rack located in the station Communications Equipment Room.
2. Install the required cabling and connectors and make the necessary connections and cross-connections between the 24-Vdc Power Supply in the Communications Equipment Room and the Kiosk Cable Termination Rack in the kiosk.

G. Elevator control panel

1. The Elevator Control Panel will be installed in Bay 3 of the kiosk under Section 14200 or Section 14240..

3.02 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 16707.

B. Supervise final wiring connections and system adjustments.

3.03 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

3.04 DEMONSTRATION

A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction

F. Demonstrate system operation.

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

END OF SECTION

SECTION 16733

KIOSK SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. The purpose of the Kiosk System is to provide the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to provide data signals to fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).

B. Facilities shall be provided in each kiosk for the station manager to monitor and control passenger station systems. A complete "Kiosk Facility" shall be provided including kiosk cabinets, system interface panels, cables, cable termination facilities, loudspeakers, wiring and all hardware needed to complete the installation of Station Monitor/Control Systems in the kiosk. The requirements for the individual monitor/control panels and systems, to be installed in the kiosk, are included in the respective System Specification Sections.

C. Cabinet Bays #1 through #6 shall be provided in the Kiosk(s) included in this Contract, as indicated on the Contract Drawings. Kiosk Cabinet Bay #7 will be furnished and installed by other trades.

D. A Cable Termination Rack shall be provided in Cabinet Bay # 3 of the kiosk(s).

1. The kiosk Cable Termination Rack shall consist of seven Terminal Strips and a Line Terminal Block. Terminal Strips shall be equally spaced on the Termination Rack. Each Terminal Strip within the kiosk Cable Termination Rack shall consist of sixty individual terminals. The kiosk Cable Termination Rack shall be provided in the kiosk(s) to terminate all cables and wires that are to be installed into the kiosk(s), with the following exceptions:

    a. Call for Aid

    b. Kiosk Multiline Telephone Cable Connections.

    c. Fire and Intrusion Alarm System cables

    d. Public Address System cables

    e. 24-MM Optical Cable

E. The fiber optic cables from the station Communications Room are terminated on the kiosk fiber optic patch panel.

F. Kiosk Data Files for the passenger station(s) shall be engineered, drawn, printed, and delivered to the Contracting Officer Representative. The Kiosk Data Files shall be designed to be a convenient source of information on the layout of the following systems:

1. Passenger Station Telephones

2. Right-of-Way and Ancillary Building Telephones

3. Passenger Station Fire Zones

4. Ancillary Building Fire Zones

5. Passenger Station Intrusion Zones

6. Ancillary Building Intrusion Zones

7. Escalators

8. Closed Circuit Television System

9. Call for Aid System

G. Laminated Fire and Intrusion Zone tables shall be provided for the passenger station(s).

H. The Escalator Display Panel provides four status indicators and one identification indicator for each of up to 16 escalators. The following indicators are provided for each escalator:

1. Direction of Travel - “UP” or “DOWN”

2. Automatic Operation - “AUTO OPER”

3. Out of Service -“OUT SERV”

4. Escalator Identification - “ESC XX” where “XX” is the number of the escalator

I. The Escalator Display Panel also includes a momentary, non-illuminating, pushbutton switch to permit a lamp test of all indicators on the panel.

J. Kiosk Monitor/Controls provide the station manager with a means to effectively manage passenger station activities. The operation of the monitor/control panels and systems, to be installed in the kiosk (except the Escalator Control Panel described in this Section), is described in the individual system specifications.

K. Kiosk Information Display System (KIDs) shall be furnished, installed, and tested by the Contractor. KIDs shall consist of, but not be limited to, the following components:

1. 47-inch flat LCD panel (Ciil CL-47PLCC68/CL-47PLC68-S or approved equal):

a. 1920 x 1080 resolution

b. IP68 rated

c. 120 VAC power input

d. Anti-reflective impact-resistant and UV protected glass

e. Ambient light

f. UL Listed

g. Weight of 120 lbs maximum

2. HDMI cable, male to male: Blackbox EVHDMI01T or approved equal

a. 28 AWG conductors

b. Copper contacts with gold plate

c. Black PVC jacket

d. Aluminum Mylar and tinned copper shielding

e. Rated for high bandwidth uncompressed video

3. Cisco Edge 300 or approved equal

a. Shall be installed in adjacent or in same bay cabinet as kiosk LAN switch.

1.02 SYSTEM DESCRIPTION

A. Description: The Kiosk System provides the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to

provide data links for fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).

B. Capacity

1. Kiosk Cabinet Bays #1 through #6C shall be furnished and installed in the kiosk(s).

2. Furnish and install the Escalator Display Panel(s) and associated conduit and cabling.

3. One set of Kiosk Data Files for each kiosk in each passenger station, and twelve additional sets of Kiosk Data Files shall be created, published, and delivered for each passenger station

4. A Kiosk Cable Termination Rack shall be furnished and installed in each kiosk.

5. An Emergency Communications Kiosk Terminal Panel shall be furnished and installed in each kiosk, Bay 2C.

6. An Elevator Control Panel (provided under Section 14240, ELECTRIC TRACTION ELEVATORS) shall be installed in the kiosk, Bay 3.

7. A Remote Fire Annunciator panel shall be furnished and installed in each Kiosk. Refer to Section 16732, FIRE ALARM SYSTEM, for description, Bay 6B.

8. A Closed Circuit Television console shall be furnished and installed in each Kiosk. Refer to Section 16851, CLOSED CIRCUIT TELEVISION SYSTEM, Bay 2B.

9. A Public Address System console shall be furnished and installed in each Kiosk. Refer to Section 16820, PUBLIC ADDRESS SYSTEM, Bay 3

10. Cat6 cables for New Electronic Payment Program (NEPP) shall land in Bay 1.

11. The fiber optic cables from the station Communications Room and Cat6 (yellow) from local cameras shall be terminated on the appropriate patch panels in Bay 2A.

12. Equipment for video management and KIDS shall be placed in Bay 2B

13. Electrical panel of appropriate size shall be provided.

C. The Kiosk Cable Termination Rack consists of seven Terminal Strips and a Line Terminal Block in Cabinet Bay 6B. Each Terminal Strip within the Kiosk Cable Termination Rack consists of sixty individual terminals. The Kiosk Cable Termination Rack terminates all cables and wires that are to be installed into the kiosk(s), with the following exceptions:

1. Fiber-optic video cables

2. Integrated Intercommunications' System cables

3. Kiosk Multi-line Telephone Cable Connections

D. The fiber optic cables from the station Communications Room are terminated on the fiber optic patch Panel in Bay 2A.

1.03 RELATED SECTIONS

A. Section 14200, HYDRAULIC ELEVATORS

B. Section 14240, ELECTRIC TRACTION ELEVATORS

C. Section 16705, COMMUNICATION EQUIPMENT AND MATERIAL

D. Section 16710, GROUNDING AND BONDING FOR COMMUNICATION SYSTEMS

E. Section 16715, COMMUNICATION ELECTRICAL POWER DISTRIBUTION

F. Section 16820, PUBLIC ADDRESS SYSTEM

G. Section 16851, CLOSED CIRCUIT TELEVISION SYSTEM

H. Section 16732, FIRE ALARM SYSTEM

I. Section 16728, CALL FOR AID SYSTEM

J. Section 16740, ACCESS CONTROL SYSTEM

1.04 REFERENCES

A. Code of Federal Regulations, Title 47 Telecommunications, Part 15 – Radio Frequency Devices (47 CFR 15), Subparts A and B

B. UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations

C. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

D. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)

E. ITU-T and EIA/TIA Recommendations

F. Standard for Fixed Guideway Transit and Passenger Rail Systems (NFPA 130)

G. National Electric Code (NEC, NFPA 70) 2014 edition

1.05 QUALITY ASSURANCE

A. Design and production tests: Refer to the Contract Documents. Submit certified test results, or provide certified test results on identical units. Furnish certified test reports showing test data and results as well as manufacturer's comments on tests.

B. Interchangeability: Refer to the Contract Documents. Furnish products of a manufacturer regularly engaged in the manufacture of applicable systems. In addition:

1. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable commercial off-the-shelf (COTS) products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices used.

2. With each system, subsystem, and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions (outdoor systems are distinct from indoor systems).

3. Equipment shall be physically and plug compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA's facilities, insofar as possible. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Authority to maintain interchangeability when competitive products that do not require such devices are determined to be unavailable (applicable to COTS major equipment items only). Custom designed and fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, all

necessary adapters and interface devices shall be provided with each item of equipment furnished, at no additional cost to the Authority.

4. Equipment shall be software compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities.

5. Major items of equipment furnished shall be within the physical size and configuration limitations specified in provisions of this Subcontract. If such specifications are not included in the provisions, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use of comparable applications elsewhere in similar WMATA facilities.

6. Exception: Lighter weight and smaller sized more modern versions of equipment are sought by the Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Authority, in order to take advantage of significant technological improvements developed by industry.

C. Qualifications of Instructor for Operation and Maintenance Training: Perform operation and maintenance training for applicable systems. Qualifications will be considered adequate when the following is demonstrated:

1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance, and trouble-shooting of the systems to be taught.

2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum 3 years documented experience.

1.07 MAINTENANCE SERVICE

A. Furnish service and maintenance of Kiosk Systems until final Acceptance.

1.08 FLOOR COVERING

A. This Article specifies the furnishing and installation of rubber floor covering and stair treads.

B. Qualifications of Manufacture: Provide the Product of an established manufacture regularly engaged in the production of the floor covering specified.

C. Deliver products to the job site in their original unopened containers clearly labeled with the manufactures' name, brand designation, and type as applicable.

D. Store products in a dry area protected from contact with soil and from exposure to the elements.

E. Handle the products in a manner that will prevent breakage of containers, damage to products and moisture intrusion.

PART 2 – PRODUCTS

2.01 TERMINALS

A. Ratings

1. Terminal Type: Modular Micro Terminal with Screw Clamp Connection
2. Wire size accommodated: #22 through #12-AWG
3. Rated Current: 27 Amps
4. Rated Voltage: 300 VDC
5. Center-to-Center Spacing: 6 mm

2.02 KIOSK CABINET BAY ASSEMBLY

A. Ratings

1. Frame Material: 16-Gauge Galvanized Steel
   1. Exposed Metal Finish: Metro Bronze color 20040 (Federal Standard 595B)
2. Desk Tops: 1-inch Marine Plywood (MARINE AA EXT-APA)
3. Hardware: Cadmium Plated
4. Desk-Top Laminate: DuPont Corian with bull nose edge
5. Desk-Top Laminate Color: Neutral White #918.Aurora
6. Blank Panels-16-Gauge Galvanized Steel, painted to match kiosk cabinets

2.03 KIOSK DATA FILE

A. Description: Each Kiosk Data File shall consist of eight or more 11-inch by 17-inch drawings.

B. Prepared Kiosk Data File drawings to document each of the following subjects:

1. Telephones (passenger station) - A cross-reference of telephone numbers and telephone locations within a passenger station
2. Telephones (Right-of-Way and Ancillary Facilities) - A cross- reference, by telephone numbers and locations, of the telephones along the right-of-way and in ancillary facilities associated with a passenger station
3. Fire Zones (Passenger Station) - A cross-reference of the designated fire zones, room numbers and room descriptions for all areas within a passenger station including ancillary facilities within the passenger station limits.
4. Fire Zones (Ancillary Facilities) - A cross-reference of the designated fire zones in remote ancillary facilities associated with a passenger station.
5. Intrusion Zones (passenger station) - A cross-reference of the designated intrusion zones, room numbers, and room descriptions for all areas of a passenger station, including ancillary facilities within the passenger station limits.
6. Intrusion Zones (Ancillary Facilities) - A cross-reference of the designated intrusion zones in remote ancillary facilities associated with a passenger station.
7. Escalators - A cross-reference of assigned escalator numbers and escalator locations within a passenger station.

8. CCTV - A cross-reference of television monitor assignments and arrangements, and television camera designations, locations and areas of coverage for all television cameras and television monitors within a passenger station.

9. Integrated Intercommunications System - A layout of platform(s) showing locations and designations of call stations

C. Rating

1. Seal Kiosk Data File drawings in a protective plastic laminate

2. Each Kiosk Data File set shall be in loose-leaf booklet form

3. Covers: 11-inch by 17-inch minimum of 60-pound punched paper with holes reinforced with plastic, cloth or metal, and sealed in a protective plastic laminate

2.04 EMERGENCY COMMUNICATIONS KIOSK TERMINAL PANEL

A. Description: The Emergency Communications Kiosk Terminal Panel consists of three terminal blocks mounted on a 16-gauge steel plate and has the following characteristics:

1. Two of the terminal blocks shall each have a minimum of 23 miniature terminals

2. The other terminal block shall have a minimum of 20 miniature terminals

2.05 FLOOR COVERING

A. Floor Covering: Heavy-duty rubber mat with ribbed surface and smooth back, all rubber compound 3/16-inch thick, terra cotta color.

B. Rubber Stair Tread: Molded tread, all rubber compound, free of blemishes, 5/16 inch thick; with light color nosing 1/2 inch wide, terra cotta color. Abrade at least 80 percent of back of tread and nosing to assure adhesion to substrate.

C. Stair Tread Adhesive: Permanent, as recommended by tread manufacturer for adhesion to galvanized steel substrate.

D. Fabricate floor covering in five pieces to fit area shown, with edges square and true, without overlapping.

E. Verify configuration of equipment in Kiosk to ensure fit of flooring within 1/16-inch tolerance.

F. Fabricate nosing of stair tread to wrap around curved ends of step, to provide uniform elevation appearance on three sides of step. Fabricate and adhere nosing so that it will not delaminate or otherwise separate from the stair tread material.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Kiosk Cabinet Bay Assembly Installation

1. Install the assembled kiosk cabinetry in the kiosk of the passenger station(s). Cabinet assembly installation shall be as follows:

a. Bays # 1, #2A, 2B, 2C and #3 as a single unit; Bays #4, #5, and #6A, 6B, and 6C as a single unit, secured to the floor of the kiosk. Kiosk cabinets may be secured to the kiosk sides with approval; however, the securing hardware shall not carry any vertical load. Hardware installed in the kiosk sides shall only be used to prevent horizontal movement.

B. Kiosk Cable Termination Rack Installation

1. Install a Kiosk Cable Termination Rack in Kiosk Cabinet Bay 6B of the kiosk. Install structure elements in the Kiosk Cabinet Bay 6B to accommodate the Terminal Strips and the Line Terminal Block of the Kiosk Cable Termination Rack.

C. Emergency Communications Kiosk Terminal Panel

1. Install an Emergency Communications Kiosk Terminal Panel in Kiosk Cabinet Bay 6B of the kiosk, as indicated on Contract Drawings. Installation shall not interfere with the Cable Termination Rack Terminal Strips. Secure Cables to the Emergency Communications Kiosk Terminal Panel to the panel to prevent interference with the Kiosk Cable Termination Rack wiring and cabling.

D. Escalator Display Panel

1. Install an Escalator Display Panel in Cabinet Bay 3 of the Kiosk.

a. Install the required wiring harness (es) between the panel and the Kiosk Cable Termination Rack in Bay 6B, and make all necessary connections and cross-connections. Install one 9-conductor, 18-AWG, shielded cable for each escalator associated with the passenger station(s) between the Kiosk Cable Termination Rack in Bay 6B of the Kiosk and the Escalator Terminal Box in the escalator wellways. Terminate the cables in the kiosk and at the escalators and make all necessary connections and cross-connections.

E. Elevator Control Panel

1. The Elevator Control Panel will be installed in Bay 3 of the kiosk under Section 14240, ELECTRIC TRACTION ELEVATORS.

F. 24-MM/ Optical Cable

1. A fiber-optic cable containing twenty-four multi-mode fibers shall be installed between the Kiosk and the Communications Room. The multimode fiber shall be 50 µm laser optimized (OM3). The cable should be terminated, on Type SC bulkhead adapters on an optical patch/termination panel on both ends, in Bay 2A.

G. One 25 pair VF plenum rated copper twisted pair cable shall be installed from the main communications room to the kiosk. This cable shall terminate on a wall mount style 110 termination block at each end and will be used to extend emergency telephone service to the Kiosk in the event of VoIP system failure. Cable must be NFPA 130 compliant.

H. Public Address Control Panel

1. Install a Public Address Control Panel in Cabinet Bay 3 of the Kiosk.

a. Install the required wiring harness (es) between the panel and the Public Address equipment located in the communication room, and make all necessary connections and cross-connections.

I. Closed Circuit Television

1. Install 2 touch screen monitors above Cabinet Bays 2B, and 2C. Install 4 viewing monitor on a mounting beam at the top of the window above Bays 2A and 2B. Install the required wiring to the workstation in Bay 2B. The Video Management Server shall be located in the communication room, connect via network switch.

J. Fire and Intrusion Control Panel

1. Install a remote Annunciator Fire and Intrusion Panel in Cabinet Bay 6B. Install all required parallel wiring to the Common Control Unit located in the communication room, and the connection to the LAN/WAN that is connected to the Head-End in the Jackson Graham/Carmen Turner Buildings OCCs.

K. Kiosk Information Display System (KIDS)

1. KIDs display shall be mounted on face of station entrance kiosk. Mounting bracket for display is preferred to be built into structure of kiosk. Location of display shall be coordinated with location of kiosk-mounted cameras. Color of display body shall match that of the kiosk. Maximize visibility to riders in the kiosk area. The unique lighting conditions, including glare, at each kiosk shall be considered to optimize visibility. Typically the KID shall be mounted on the kiosk front face. The Contractor may recommend another kiosk face if it thinks it may provide better utility, visibility and usefulness to passengers. WMATA shall have final approval of any recommended deviations, and approval must be received before installation may begin. HDMI cables shall not exceed 30 feet in length. Final integration of KIDs will be performed by WMATA.

3.02 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems

B. Inspect final wiring connections and supervise or perform system adjustments

3.03 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation

3.04 FLOOR COVERING

A. After installation, prohibit traffic and protect floor covering with plastic sheets or heavy building paper with taped joints. Use plywood protection boards when moving equipment. Maintain protection until Acceptance.

END OF SECTION

SECTION 16740

COMMUNICATIONS – ELECTRONIC ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This section specifies a complete and operational Access Control system for Authority-wide including WMATA's rail system, parking garages, bus divisions, and support facilities.

B. Related Sections:

1. Section 08331 – Overhead Coiling Doors
2. Section 08710 - Finish Hardware
3. Section 16703 – Communications Standard Specifications-Engineering Services
4. Section 16704 – Communications Standard Specifications-Installation
5. Section 16705 – Communications Standard Specifications-Equipment & Material
6. Section 16706 – Communications System Submittals & Services
7. Section 16707 – Communications Quality Assurance & Testing
8. Section 16710 – Communications Grounding
9. Section 16715 – Communications Electrical Power Distribution
10. Section 16120 - Wire Cable, and Busways
11. Section 16733 – Communications – Kiosk Systems

1.02 REFERENCES

A. Code, Regulations, Reference Standards, and Specifications:

1. National Electrical Code (NEC)
2. NFPA 130 – Standard for Fixed Guideway Transit Systems
3. UL 1076 – Proprietary Burglar Alarm Units and Systems
4. ADA Standards
5. Electronics Industries Alliance (EIA) Standard RS 170
6. Federal Standard 595B, Colors Used in Government Procurement
7. WMATA Design and Wiring Standards rev1 May 2014
8. WMATA Standards Access Control drawings

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Equipment manufacturer: Select a manufacturer who is engaged in production of similar Access Control products and accessories.
2. Equipment supplier: A manufacturer authorized distributor of specified products with minimum of three years documented experience.
3. Equipment installer: A manufacturer authorized installer of specified products with service facilities within 100 miles of WMATA.

B. Coordination

1. Installer shall coordinate Access Control installation with all other concurrently running work at the location specified under this task.

C. The Contractor shall develop test procedures and obtain Engineer approval prior to final acceptance testing.

D. The Contractor shall perform progressive tests in accordance with the approved test procedure to verify compliance with specified system performance requirements, including but not limited to proper component operation, and software operations.

1. The Contractor's Quality Assurance Engineer shall witness all progressive testing.

2. All discrepancies found during testing shall be corrected and test reports submitted prior to scheduling end-to-end testing.

3. The Contractor shall notify the Engineer prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.

E. End-to-End Test:

1. The Contractor shall demonstrate the proper functioning of the completed Access Control system.

2. Each access control device shall operate as specified in the design drawings and be properly configured on the access control software.

3. The Contractor shall submit certified test reports within 10 working days after completion of field tests.

1.04 SUBMITTALS

A. Submit the following for approval in accordance with Section 16706 and with the additional requirements as specified for each:

1. Design Drawings

a. Proposed changes and revised equipment layouts

b. System riser diagrams to include source of power.

c. Access Control equipment mounting details.

d. Completed door controllers and equipment schedules

2. Product Data: Provide product data sheets for each item of equipment and resubmittal for equipment which changes as a result of required modification.

3. Manufacturer's Installation Instructions

a. Indicate application conditions and limitations of use, stipulated by Product testing agency.

b. Include instructions for storage, handling, protection, examination, preparation, installation, and start-up of Product.

B. As-Built Documents: Prior to Substantial Completion, develop As-Built documents as follows:

1. As-Built Drawings of the Access Control system installation to include, but not be limited to camera layouts, communication and power cable pathways and wiring, equipment details and equipment schedules.

2. Approved copies of each submittal

C. Operation and Maintenance (O & M) manuals

1. Complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of personnel.

2. Include descriptions of systems, background information, and complete procedures for adjustment, calibration, replacement, and repair of components in system.

3. Make data contained specific for and exclusive to the systems and equipment for the work of this Contract.

4. Field test data and reports.

D. Certification

1. Certificates from manufacturers verifying that equipment conforms to the specified requirements.

1.05 OPERATION AND MAINTENANCE TRAINING

A. In accordance with the General Requirements.

PART 2 - PRODUCTS

2.01 SECTION INCLUDES:

A. Access Control Hardware

B. Software Licensing

2.02 PoE DOOR CONTROLLER

A. Make and Model: Honeywell PW6K1ICE or approved equal

B. Power Input:

1. Power over Ethernet (PoE) 12.95W

2. 12 VDC, 200 mA min, 900 mA max

C. Power Output:

1. 12 VDC @ 650 mA (reader and AUX outputs combined)

2. 10.3 – 12.6 VDC reader output @ 150 mA max

3. 10.7 – 13.0 VDC AUX power output @ 700 mA max

D. Environmental Factors:

1. Operating temperature: 0°C to 70°C (32°F to 158°F)

2. Humidity: 10 - 95% RHNC

3. Storage conditions: -55°C to 85°C (-67°F to 185°F)

E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface

F. Inputs: 2 supervised, programmable end of line resistors, 1k/1k-ohm 1% 1/4 watt standard, and dedicated tamper switch

G. Relays: 2 outputs, Form-C contacts: 2A @ 30 VDC

H. Reader Module:

1. Configuration: wiegand or OSDP

2. Reader Power: 12VDC 10% or local power supply

3. Reader Data Inputs: Two TTL reader ports or one 2-wire RS-485 reader port

capable of supporting two readers

I. Cable Requirements:

1. Power: 1 twisted pair, 18 AWG
2. Ethernet: CAT-6
3. Reader Data (TTL): 18 AWG – 6 conductors, 500 ft. (150 m) max
4. Reader Data (RS-485): 24 AWG, 120Ω impedance, twisted pair with shield, 4,000 ft. (1,219 m) max
5. Alarm Input: 1 twisted pair per input (30Ω max loop resistance)

J. Compatibility:

1. Access Control Software: the door controller shall be compatible with the access control server. The access control software configures the door controller. The door controller sends a transaction log on real time to the access control server through the WMATA's WAN network.
2. Card Readers: the reader module which is part of the door controller shall be compatible with the wiegand output of Mifare Plus S and 125 kHz proximity readers.

K. Warranty: 1-year warranty

2.03 PoE DOWNSTREAM DOOR CONTROLLER

A. Make and Model: Honeywell PW6K1R1E or approved equal. Up to 26 PW6K1R1E downstream boards can be connected to PW6K1ICE controller board

B. Power Input:

1. Power over Ethernet (PoE) 12.95W
2. 12 VDC, 200 mA min, 900 mA max

C. Power Output:

1. 12 VDC @ 700 mA max (reader and AUX outputs combined)
2. 10.3 – 12.6 VDC reader output @ 150 mA max
3. 10.7 – 13.0 VDC AUX power output @ 700 mA max

D. Environmental Factors:

1. Operating temperature: -40°C to 75°C (-40°F to 167°F)
2. Humidity: 10 - 95% RHNC
3. Storage conditions: -55°C to 85°C (-67°F to 185°F)

E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface

F. Inputs: 4 unsupervised/supervised, Programmable End of Line resistors, 1k/1k-ohm 1% 1/4 watt standard, and dedicated tamper switch

G. Relays: 2 outputs, Form-C contacts: 5A @ 28 VDC

H. Reader Module:

1. Reader Power: 12VDC 10% or local power supply
2. Reader Data Inputs: Two TTL reader ports or one 2-wire RS-485 reader port capable of supporting two readers

I. Cable Requirements:

1. Power: 1 twisted pair, 18 AWG

2. Ethernet: CAT-5 (minimum)

3. Reader Data (TTL): 18 AWG – 6 conductors, 500 ft. (150 m) max

4. Reader Data (RS-485): 24 AWG, 120Ω impedance, twisted pair with shield, 4,000 ft. (1,219 m) max

5. Alarm Input: 1 twisted pair per input (30Ω max loop resistance)

J. Reader Data Inputs: Two TTL reader ports or one 2-wire RS-485 reader port capable s:

K. Compatibility:

1. Access Control Software: the downstream door controller shall be compatible with the access control server. The access control software configures the downstream door controller. The downstream door controller sends a transaction log to the access control server on real time through the WMATA's WAN network.

2. Card Readers: the reader module which is part of the door controller shall be compatible with the wiegand output of Mifare Plus S and 125 kHz proximity readers.

L. Warranty: 1-year warranty

2.04 CARD READER WITH KEY PAD

A. Make and Model: Oberthur ID One Secure Pac reader. Model 125 14443 DF PIN 500-5045 with WMATA profile or approved equal

B. Power Supply: 7 – 24 VDC (12 VDC recommended)

C. Current Consumption @ 12 VDC:

1. Average: 110 mA

2. Peak: 171 mA

D. Typical Read Range:

1. Mifare ISO card: 60 mm (2.4 inch)

2. LF Proximity ISO card: 30 – 60 mm (1.2 – 2.4 inch)

E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface

F. Operating Temperature: -25°C - 65°C (-15°F - 150°F)

G. Protection Class: IP54

H. Cards: Mifare Plus S, 26-Bit and 37-Bit 125 kHz proximity cards.

I. Warranty: 2-year warranty

2.05 CARD READER WITHOUT KEY PAD

A. Make and Model: Oberthur ID One Secure Pac reader. Model 125 14443 DF 500-5045 with WMATA profile

B. Power Supply: 7 – 24 VDC (12 VDC recommended)

C. Current Consumption @ 12 VDC:

1. Average: 110 mA

2. Peak: 146 mA

D. Typical Read Range:

1. Mifare ISO card: 60 mm (2.4 inch)

2. LF Proximity ISO card: 30 – 60 mm (1.2 – 2.4 inch)

E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface

F. Operating Temperature: -25°C - 65°C (-15°F - 150°F)

G. Protection Class: IP54

H. Cards: Mifare Plus S, 26-Bit and 37-Bit 125 kHz proximity cards.

I. Warranty: 2-year warranty

2.06 MOTION SENSORS

All motion sensors shall be able to be powered by either 12VDC or 24 VDC.

A. Ceiling Mount: high performance panoramic, dual element sensor Bosch DS938Z or approved equal

B. Wall Mount: high performance panoramic, dual element sensor Bosch DS778Z or approved equal

C. Request to Exit (REX) Motion Sensor: Bosch DS150i or Securitron XMS, or approved equal

2.07 CREDENTIALS

A. Mifare Plus S which supports ISO/IEC 14443 Type A with communication speed up to 848 kbit/s. Make and Model: NXP model MF1SPLUS6001DA4 in MOA4 module form

2.08 REQUEST TO EXIT (REX) PUSHBUTTON

A. Plastic button: Alarm Controls TS-2 or approved equal

B. Metal button: Schlage Locknetics 620 series or approved equal

2.09 DOOR STRIKES

A. Refer to the Access Control Standard Drawings for door details and door strikes type. Door strikes to be able to be powered by either 12VDC or 24VDC.

2.010 MAGNETIC LOCKS (MAGLOCKS)

A. All Maglocks shall be able to be powered by either 12VDC or 24VDC. Make/Model: Securitron M62 series or approved equal

2.011 DOOR POSITION SWITCH

A. Make and Model: Sentrol 1076C or approved equal. Similar color of the door frame.

2.012 POWER SUPPLY

A. All power supplies to deliver at least 2 Amps @ 12VDC or 24 VDC. Make/Model: SDC 602RF or approved equal

2.013 ACCESS CONTROL ENCLOSURE

Refer to the access control enclosure standard drawing for devices installed inside and mounting details

2.014 SOFTWARE LICENSE

A. Stand Alone Applications: access control software compatible with card readers described above and the use of Mifare Plus S cards. Pro-Watch corporate edition or approved equal

B. Addition to the existing system: new access controlled doors shall be configured on the existing access control software adding the proper amount of card licenses

PART 3 - EXECUTION

3.01 DESIGN

A. Submit the optimum design layout of the new access controlled doors and devices specifications prior to installing any equipment. The Contractor will use the layout to determine the adequacy of the design and, in conjunction with a field survey, determine the exact location of each Access Control device

3.02 INSTALLATION

A. Installation of devices covered by these specifications shall comply with the Access Control Standard drawings

B. Installation of access control devices shall be performed in a neat and professional manner and retain all elements of the rail and bus system's architectural excellence

C. Installation of access control devices shall be coordinated with work of other trades

D. Access Control equipment shall be installed in accordance with manufacturer's instructions

E. Access Control equipment shall not be installed over tracks or extend beyond the inside of the platform edge granite unless otherwise specified and approved.

F. All cables shall be installed and tested in accordance with the most current WMATA Design and Wiring Standards

G. For conduit, raceways and cabinet installation see Section 16130

H. For wire cable and busways installation, see Section 16120

3.03 SOFTWARE CONFIGURATION

A. Configure and document all parameters chosen during the configuration of all new devices the access control software

B. The Contractor shall configure new devices on the access control software with the supervision of the WMATA engineer

3.04 FIELD QUALITY CONTROL

A. Design and Performance Testing: Perform tests and submit results in accordance with the General Provisions, certified test results for the Access Control system installed under this contract

B. Acceptance Testing:

1. Furnish equipment required to perform tests
2. Comply with WMATA approved system testing
3. Perform approved tests to verify that the Access Control systems comply with requirements shown and specified

C. The Contractor is responsible for testing all power and communications signals in accordance with WMTA's Design and Wiring Standards

3.05 DEMONSTRATION

A. Conduct walking tour of Project and briefly describe function, operation and maintenance of the system components

B. Demonstrate operation and maintenance of the system to WMATA personnel two weeks prior to date of Substantial Completion

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing,

maintenance and shutdown of each item of equipment at equipment location

E. Prepare and insert additional data in operations and maintenance manuals as needed for additional data becomes apparent during instruction

3.06 SPARE PARTS

A. In accordance with special conditions and the following:

1. Provide spare parts and/or equipment for no less than 10% of new items that are added to WMATA's inventory under this task

PART 4 - END OF SECTION

SECTION 16791

COMMUNICATIONS - MOBILE RADIO SYSTEM

PART 1 - GENERAL

1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

A. This Section describes the basic components of the WMATA Mobile Radio System (MRS). The WMATA Mobile Radio System consists of a Metrorail Mobile Radio Subsystem, a Primary Local Jurisdictional (PLJ) Radio Subsystem, and a Terminal Supervisor's Radio at End-Of-Line Stations.

B. The purpose of the WMATA Metrorail Mobile Radio Subsystem is to provide two-way voice communications between control consoles, provided by others, located within the WMATA Rail Operations Control Center (RAIL OCC), and portable, vehicular and rail car radios, utilized throughout the WMATA Rail Rapid Transit System and the Washington Metropolitan Area.

C. The purpose of the Primary Local Jurisdictional (PLJ) Radio Subsystem is to provide two-way voice communications between control center facilities of local Fire Department, Police Department, and Emergency Medical Services (EMS) authorities and their corresponding portable radios, when utilized within the tunnel and underground station areas of the WMATA Rail Rapid Transit System.

D. The purpose of an End-Of-Line Terminal Supervisor's Radio is to provide limited communications between the End-Of-Line Terminal Supervisor and train operators near or at the station platform.

E. The WMATA Rail Mobile Radio Subsystem (MRS) is a frequency modulated voice radio system operating in the 490 MHz portion of the frequency band. The WMATA MRS consists of five networks: Operations 1, 2, 3, Maintenance, and Metro Transit Police Department (MTPD). Each network operates as a separate system with its individual transmitter/receiver (T/R) equipment, control consoles, control logic, frequency(s), and portable and vehicular radios.

F. The WMATA Rail MRS consists of surface and underground radio base stations located along the WMATA right-of-ways to provide radio coverage for the entire WMATA Rail Rapid Transit System. Surface radio base stations (not included in this contract) provide coverage for all surface and aerial portions, while underground radio base stations (required under this contract) cover underground passenger stations and tunnel areas of the WMATA Rail Rapid Transit System.

G. Each underground radio base station includes one transmitter/receiver for the Operations Network, the Maintenance Network, and the MTPD Normal Network. In addition, the MTPD Emergency Network includes a second receiver.

H. All network radios and the second MTPD receiver are multiplexed onto a single slotted coaxial cable antenna system installed in underground stations and tunnels. Each radio is connected to the Rail OCC by a 4-wire, 4 kHz voice channel of the Carrier Transmission System (CTS).

I. The Operations and Maintenance Network radios are connected to master control consoles located in the Jackson Graham Building. The MTPD Network is connected to its master

control console through an interface arrangement in the Communications Equipment Room at the Jackson Graham Building.

J. The PLJ Radio Subsystem is a frequency-modulated voice radio system operating in the 150-155 MHz, the 450-512 MHz, and in the 850 MHz portions of the frequency band. The PLJ radio base stations shall be co-located in the passenger station Communications Equipment Rooms with the WMATA Rail MRS base stations. The PLJ radios provide coverage for PLJ portable radios in underground stations and tunnels.

K. The PLJ radio base stations are multiplexed onto the same slotted coaxial cable antenna system used by the WMATA Rail MRS. Each PLJ network radio base station is connected to its Local Jurisdiction Radio Control Facility by leased telephone lines within the station.

L. The Slotted Coaxial Cable Antenna System shall act as the medium for receiving/transmitting the radio frequency waves to/from the WMATA Rail Mobile Radio Subsystem and the PLJ Radio Subsystem Base Stations.

M. A WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility shall be provided in the Terminal Supervisor's Office in an End-Of-Line passenger station. The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel within the passenger station.

N. Vehicular and portable radios shall be provided under this contract. The contractor shall program and test the portable radios for operation with the MRS.

O. Metro Transit Police Department Network (MTPD) Operation

1. In the normal mode of operation, a call can be initiated by a portable radio, a vehicular radio, or the MTPD Network Master Control Console using the primary frequency (Channel 1 on the portable and vehicular radios). The operation is simplex, push-to-talk. The call is initiated by operating the push-to-talk switch and speaking into the microphone.
2. Emergency Mode Operation - In emergency mode operation, a call can be initiated by a portable radio or a vehicular radio using the auxiliary frequency (Channel 2). The call is initiated by operating the push-to-talk switch and speaking into the microphone.
3. The MTPD Network Master Control Console monitors the normal mode channel and the emergency mode channel simultaneously at all times. An emergency mode call will be received by the MTPD Network Master Control Console even if a normal mode call is in progress. Transmission from the MTPD Network Master Control Console is on the primary frequency.
4. When a portable radio or a vehicular radio is in the Channel 2 position, it receives on Channel 1 (primary frequency) and transmits on Channel 2 (auxiliary frequency).
5. In the emergency mode operation, simplex cross-patch is also available by operator initiation at the MTPD Network Master Control Console by interconnecting selected base stations. In this function, the received transmissions on the auxiliary frequency (Channel 2) from a portable or vehicular radio are retransmitted on the primary frequency (Channel 1) by Voice Operated Relay (VOX) console circuitry. This function permits portable-to-portable communications on a limited basis between radios located in other tunnel areas and the surface.

P. Each Primary Local Jurisdictional Radio Subsystem network operates as duplex, push-to-talk. A call can be initiated by a portable radio or the control facility by operating the push-to-talk switch and speaking into the microphone. Portable-to-portable radio operation is available for each network within the tunnel and underground passenger station areas. (In

addition, communications between portable radios in the tunnel and underground passenger station areas and vehicular and portable radios above ground is available).

1.02 SECTION INCLUDES

A. WMATA Rail Mobile Communications System

B. Primary Local Jurisdicational Radio Subsystem

C. End-Of-Line Terminal Supervisor's Radio.

1.03 UNIT PRICES

A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

1.04 RELATED SECTIONS

A. Section 16705 -Communications Standard Specifications - Equipment & Material

B. Section 16706 - Communications System Submittals & Services

C. Section 16707 - Communications Systems Quality Assurance & Testing

D. Section 16710 -Communications Grounding

E. Section 16715 - Communications Electrical Power Distribution.

1.05 REFERENCES

A. National Electric Code (NEC).

B. Federal Communication Commission (FCC).

1.06 SYSTEM DESCRIPTION

A. Description: The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel within the passenger station.

B. Capacity:
1. The contractor shall design, furnish, and install an End-Of-Line Terminal Supervisor's mobile radio in each end-of-line passenger being built.
2. The contractor shall design, furnish, and install an End-Of-Line Terminal Supervisor's mobile radio antenna in each end-of-line passenger station being built.
3. The contractor shall design, furnish, and install RF coaxial cable between the mobile radio and the antenna in each end-of-line passenger being built.
4. The contractor shall design, furnish, and install the necessary PLJ Radio Subsystem within the tunnels and under ground passenger stations.
5. The contractor shall design, furnish, and install the necessary MRS Radio System within the tunnels and under ground passenger stations.

1.07 SYSTEM PERFORMANCE REQUIREMENTS

A. Frequency Stability: ±0.0002% of assigned carrier frequency between 30˚C and +60˚C.

B. Audio Response: Within +1 and -3dB of 6dB per octave pre-emphasis 300-3000Hz referenced to1000 Hz.

C. Audio Distortion: Less than 3% deviation @ 1000 Hz @ 1 kHz.

D. RF Impedance: 50 ohms.

E. Modulation: 16F3, ± 5 kHz for 100% deviation at 1 kHz.

1.08 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.

C. Product Data: Provide showing electrical characteristics and connection requirements for each component.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.09 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

1.10 MAINTENANCE SERVICE

A. Furnish service and maintenance of Mobile Radio System until Final Completion.

PART 2 - PRODUCTS

2.01 END-OF-LINE TERMINAL SUPERVISOR'S MOBILE RADIO

A. Manufacturers:
1. Ericsson-GE MVS Mobile Radio Model No. MLS II with Model No. MLMK1P control panel.
2. Motorola MaxTrac 300, 40-Watt, 16-Channel Radio.
3. Or approved equal.

B. Ratings:
1. Frequency: 490 MHz band
2. RF Input impedance: 50-ohms.
3. Power Input: 120-Vac, 60-Hz.
4. Equipped with desk microphone.

2.02 TERMINAL SUPERVISOR'S MOBILE RADIO ANTENNA

A. Manufacturer:
   1. Decibel Products Model DB201 (or approved equal)

B. Description: Omni-directional, roof-mounted, UHF ground-plane antenna complete with mounting hardware.

C. Ratings:
   1. Impedance: 50-ohms.
   2. Minimum power: 100-watts.
   3. Frequency Range: 490 MHz band
   4. Minimum Vertical beamwidth: 75-degrees

2.03 PLJ POLICE, FIRE DEPARTMENT, and EMS RADIO BASE STATIONS

A. Manufacturers:
   1. Ericsson-GE Master III Base Station
   2. Motorola MRS 2000
   3. Or approved equal.

B. Description:
   1. Equipped for PLJ Police and Fire Department frequencies as indicated under Frequency Assignments.
   2. Equipped with four channels for duplex operation
   3. Rated Power of 100 watts RF output power on a continuous basis
   4. Receiver shall be equipped for operations utilizing low noise pre-amplifiers
   5. Tone controlled.
   6. Continuous
   7. Shall be shielded against problems due to collocated site RF sources
   8. Shall have a receiver voting encoder.
   9. Shall have control line protection and compensation
   10. Shall have power line protection
   11. The PLJ Police Department Radio Base Station, PLJ Fire Department Radio Base Station, and the PLJ EMS Radio Base Station shall be enclosed in a single equipment cabinet

2.04 FLEXIBLE FOAM-DIELECTRIC ½-INCH COAXIAL CABLE

A. Manufacturers:
   1. Andrew Corporation Superflexible HELIAX Model No. FSJ4RN-50B (or approved equal).

B. Ratings:
   1. Impedance: 50 ohms.
   2. Jacket: Non-halogenated, flame-retardant and smoke-resistant

PART 3 - EXECUTION

3.01 INSTALLATION

A. End-Of-Line Terminal Supervisor's Office
   1. Install the End-Of-Line Terminal Supervisor's Mobile Radio, as shown on the contract drawings, in a location approved by the Engineer.
   2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle in the Terminal Supervisor's Office.

3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

B. PLJ Police, Fire Department, and EMS Radio Base Stations
1. Install the PLJ Radio Subsystem, as shown on the contract drawings, in a location approved by the Engineer.
2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle in the Terminal Supervisor's Office.
3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

C. Metrorail Mobile Radio Subsystem
1. Install the Metrorail Radio Subsystem, as shown on the contract drawings, in a location approved by the Engineer.
2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle in the Terminal Supervisor's Office.
3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

3.02 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 16707.

B. Supervise final wiring connections and system adjustments.

3.03 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

3.04 DEMONSTRATION

A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

F. Demonstrate system operation.

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

END OF SECTION

SECTION 16791
COMMUNICATIONS - COMPREHENSIVE RADIO COMMUNICATION SYSTEM

PART 1 - GENERAL

1.1 SECTION DESCRIPTION AND BASIC REQUIREMENTS

A. This Section describes the basic components of the WMATA Comprehensive Radio Communication System (CRCS). The WMATA Radio Communication System consists of a Comprehensive Radio Communication System (CRCS) Subsystem above and below Ground, a Public Safety Radio System (PSRS) Subsystem below ground, a Terminal Supervisor's Radio at End-Of-Line Stations, a Mobile Radio at Rail Yard Tower stations and Gate House, a Distributed Antenna System for providing Coverage at WMATA Stations, buildings and Wayside Structures and Tunnels.

1.2 SECTION INCLUDES

A. End-Of-Line Terminal Supervisor's Radio.

B. Mobile Radio at Rail Yard Tower stations and Gate House

C. Distributed Antenna System for providing Coverage at WMATA Stations, buildings and Wayside Structures

1.3 RELATED SECTIONS

A. Section 16705 -Communications Standard Specifications - Equipment & Material

B. Section 16706 - Communications System Submittals & Services

C. Section 16707 - Communications Systems Quality Assurance & Testing

D. Section 16710 -Communications Grounding

E. Section 16715 - Communications Electrical Power Distribution.

1.4 REFERENCES

A. National Electric Code (NEC - latest).

B. Federal Communication Commission (FCC part 15).

C. National Fire Protection Association (NFPA 130 / NFPA 101)

D. Underwriters Laboratories (UL)

1.5 SYSTEM DESCRIPTION

A. Description: The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel (usually train operators) within the passenger station interfacing with the existing WMATA Simulcast radio system.

Capacity: An End-Of-Line Terminal Supervisor's mobile radio, antenna and RF coaxial cable shall be designed, furnished, and installed in the end-of-line passenger station (Station).

B. Description: The WMATA Mobile Radio at Rail Yard Tower stations and Gate House Provides two-way voice communications between the Rail Yard Tower towers, gate House and WMATA personnel (train operators, maintenance personnel within the yard facility interfacing with the existing WMATA Simulcast radio system.

Capacity: The Rail Yard Tower and Gate House mobile radio, antenna and RF coaxial cable shall be designed, furnished, and installed at those locations.

C. Description: The WMATA Distributed Antenna System (DAS) shall provide mobile radio coverage in poor radio coverage areas by repeating existing above-ground simulcast radio signal communications in areas of metro rail facilities having deficient radio coverage. The Off-The-Air Radio Repeater System shall be designed to support rail operations and maintenance, transit police, and support the Integration of the Public Safety Radio System (PSRS)

Capacity: The contractor shall use the installed Radiax Cable provided by WMATA to create a Distributed Antenna System (DAS) for use in the underground sections of WMATA rail system. The DAS shall consist of Below Station Bi-Directional Amplifier (BDA) sites and Tunnel BDA sites. The Contractor shall perform a link budget analysis to determine the placement of BDAs, cabling, and radiating elements. The contractor shall expand the WMATA supplied Radiax system to obtain required coverage. The Contractor shall be responsible for installation of additional radiating cable and or antennas (Omni or panel), in the ancillary spaces, sufficient to achieve stated system requirements for minimum acceptable coverage. All rooms and spaces accessible to personnel within or near the ancillary location shall be provided with minimum acceptable coverage. This includes the entire egress route to the surface (stairs or ladder); if such a personnel egress shaft exists. Ancillary Space DAS components shall meet the following minimum requirements:

Radiating Cable:	Same specifications as the existing tunnel "WMATA DAS" radiating cable
Antennas:	Omni or Panel, as required for area covered 490 to 1000 MHz broadband or better.

D. The purpose of the WMATA CRCS Subsystem is to provide two-way voice communications between control consoles to Rail Operations Control Center (RAIL OCC), and portable, vehicular and rail car radios, the Washington Metropolitan Area Transit Police Department (MTPD), Bus, Maintenance departments utilized throughout the WMATA Transit System in tunnels, stations and all areas above ground where the WMATA service extends.

E. The purpose of the Public Safety Radio System (PSRS) Radio Subsystem is to provide two-way voice communications between control center facilities of local Fire Department, Police Department, and Emergency Medical Services (EMS) authorities and their corresponding portable radios, when utilized within the tunnel and underground station areas of the WMATA Transit System.

F. The purpose of the Mobile Radio at Rail Yard Tower station and guard booth is to provide limited communications between the tower, train operators entering and leaving yard buildings and other areas within the facility.

G. The purpose of an End-Of-Line Terminal Supervisor's Radio is to provide limited communications between the End-Of-Line Terminal Supervisor and train operators near or at the station platform.

H. The purpose of the Distributed Antenna System Stations, buildings, Wayside Structures and tunnels is to provide adequate radio communications coverage to each room, public and non-public space within these facilities to which MTPD, emergency responders, maintenance or WMATA employees can access using their radios throughout the CRCS coverage area.

I. The WMATA Comprehensive Radio Communication System (CRCS) is a frequency modulated, UHF T-Band, (operating in the 470-512 MHz portions of the frequency band) digital, single-cell simulcast trunked Motorola Smart Zone 3.0z radio system, used for communicating with radio users throughout the entire WMATA service area.. The WMATA CRCS consists of several networks: Operations 1, 2, 3, 4, Metro Transit Police Department (MTPD) Maintenance and Bus. Each network operates as a separate system with its individual transmitter/receiver (T/R) equipment, control consoles, portable and vehicular radios.

J. The WMATA CRCS consists of surface and underground Bi-Directional Amplifier (BDA) network located along the WMATA right-of-ways to provide radio coverage for the entire WMATA Transit System. The Surface design composed of 10 remote above ground sites, 15 voice channels, 4 data AVL (bus) channels, one mobile data channel and one paging channel to provide coverage for all surface and aerial portions, while an underground BDA system cover underground passenger stations and tunnel areas of the WMATA Transit System.

K. The underground CRCS is divided up into 26 segments. Each segment consists of several Bi-Directional Amplifiers (BDA) cascaded together. The first Amplifier in the chain is a fiber-fed BDA connected to the main Prime site location at JGB. All BDAs are cascaded along the tunnel segment using a single slotted coaxial cable antenna system installed in underground stations and tunnels.

L. The PSRS Radio Subsystem is a frequency-modulated voice radio system operating in the 850 MHz portions of the frequency band. The Public Safety Radio System (PSRS) is multiplexed into the same radiating cable used by WMATA CRCS using a Cross-Band Coupler (CBC). The PSRS subsystem is similar design utilizing the 850 MHz frequency band and associated components. The PSRS Head-end equipment shall be co-located in the passenger station Communications Equipment rooms and BDAs inside the tunnels. The PSRS radios provide coverage for PSRS portable radios in underground stations and tunnels.

M. The Slotted Coaxial Cable Antenna System shall act as the medium for receiving/transmitting the radio frequency waves to/from the WMATA Comprehensive Radio Communication Subsystem and the Public Safety Radio System (PSRS) Subsystem. T

N. The Slotted Coaxial Cables Antenna System shall be installed as required to achieve 95% coverage at a 3.4 DAQ level requirements throughout the Metrorail Project coverage area.

O. A WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility shall be provided in the Terminal Supervisor's Office in an End-Of-Line passenger station. The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel within the passenger station.

P. Distributed Antenna System shall be designed using any combination of BDAs (fiber-fed, off-air or RF-fed), Optical master units, Antennas (Omni, Yagi, Flat panel), radiating coax and non-radiating coax for providing Coverage at WMATA Stations, buildings, Wayside Structures and tunnel segments.

Q. Vehicular and portable radios shall be provided to interface and operate over the CRCS system built on Motorola Smartzone technology

R. Each Public Safety Radio System Subsystem network operates as duplex, push-to- talk. A call can be initiated by a portable radio or the control facility by operating the push-to- talk switch and speaking into the microphone. Portable-to-portable radio operation is available for each network within the tunnel and underground passenger station areas. (In addition, communications between portable radios in the tunnel and underground passenger station areas and vehicular and portable radios above ground is available).

1.6 SYSTEM PERFORMANCE REQUIREMENTS – RADIO

A. Radio:

1. Frequency range: 450-520 MHz
2. Channel Spacing: 12.5/25 KHz
3. Maximum Frequency Separation: Full Band split
4. Rated RF Output Adj: 1 to 5 Watts
5. Frequency Stability: ±0.0002% of assigned carrier frequency between 30°C and +60°C.
6. Audio Response: Within +1 and -3dB of 6dB per octave pre-emphasis 300-3000Hz referenced to1000 Hz.
7. Emissions (Conducted and Radiated): -70 dBc
8. Audio Distortion: Less than 3% deviation @ 1000 Hz @ 1 kHz.
9. RF Impedance: 50 ohms.
10. Modulation: 16F3, ± 5 kHz for 100% deviation at 1 kHz.
11. Receive Analog Sensitivity (12 dB SINAD): 0.25µV
12. Receive Digital Sensitivity (1% BER/ 5% BER)): 0.35µV / 0.25µV

B. Distributed Antenna System (DAS)

1. Frequency range: U/L (489.5125 – 490.9625 MHz, 496.3375 – 496.6125MHz)
   D/L (492.5125 – 493.9625 MHz, 499.3375 – 499.6125MHz)
2. Channel Spacing:12.5/25 KHz
3. Channel Bandwidth: User selectable, 15 KHz, 30 KHz DSP filters Both either Low Selectivity or High Selectivity400 KHz or 1.5 MHz band select filter
4. Rated RF Output Adj: 1 to 5 Watts per Band
5. RF Impedance: 50 ohms.
6. Maximum Gain: 80 dB
7. Gain Adjustment: 0 – 30dB in 1dB steps per channel
8. Passband Ripple: +/-2dB
9. Uplink Noise Figure: < 8dB (at maximum gain).

PART 2 - PRODUCTS

2.1 END-OF-LINE TERMINAL SUPERVISOR'S MOBILE RADIO ANTENNA RAIL YARD TOWER RADIO ANTENNA AND GATE HOUSE RADIO ANTENNA

A. Manufacturers:
1. Motorola APX4500 (M22SSS9PW1AN) radio R2 with:
   - Dash mount (G66AW)
   - Control station desk mic(W382AM)
   - Control Station Power supply (G91AE)
   - Trunking Baud Single System (QA01749AB)
   - Base Station APEXWWM (W665BJ)
   - Dash mount 02 wwm (G66AW)
   - APX 02 Control Head (GA00804AB)
2. Or approved equal.

B. Ratings:
1. Frequency: 450-520 MHz band
2. RF Input impedance: 50-ohms.
3. Power Input: 120-Vac, 60-Hz. adaptor
4. Equipped with desk microphone and tray.

2.2 FLEXIBLE FOAM-DIELECTRIC ½-INCH COAXIAL CABLE FOR DAS

A. Manufacturers:
1. Commscope FXL-540-NHR
2. Or approved equal

B. Ratings:
1. Impedance: 50 ohms.
2. Jacket: Non-halogenated, fire retardant polyolefin
3. Dielectric Material: Foam PE
4. Operating Temperature -30 °C to +70 °C (-22 °F to +158 °F)
5. Peak Power: 41.8 kW
6. Operating Frequency Band: 100 – 8800 MHz
7. Fire Retardancy Test Method: IEC 60332-3-24 | UL 1666/CATVR/CMR
8. Smoke Index Test Method : IEC 61034
9. Toxicity Index Test Method : IEC 60754-1 | IEC 60754-2

2.3 RADIAX COAXIAL RADIATING CABLE 1-5/8-INCH for DAS

A. Manufacturers:
1. Commscope RCT7-WBC-2A-RNAM
2. Or approved equal

B. Ratings:
1. Impedance: 50 ohms.
2. Jacket: Non-halogenated, fire retardant polyolefin
3. Tape Barrier: Mica
4. Dielectric Material: Foam PE
5. Operating Temperature -30 °C to +80 °C (-22 °F to +176 °F)
6. Peak Power: 302.0 kW
7. Operating Frequency Band: 50 – 2700 MHz
8. Fire Retardancy Test Method: IEC 60332-3-24 | IEC 60332-3C-24 | NFPA-130-2010

9. Smoke Index Test Method : IEC 61034
10. Toxicity Index Test Method : IEC 60754-1 | IEC 60754-2

2.4 RADIO REPEATER AND DONOR ANTENNAS FOR DAS SYSTEM

A. Manufacturers:
1. MARS Antenna and RF system - MA-CQ27-1X (OMNI 490/800 MHz)
2. Sunol Sciences – LP425PCB (Broadband Directional Antenna 490/800 MHz)
3. Sunol Sciences – LP425 (Broadband Directional Antenna 490/800 MHz)
4. Telewave, Inc. – ANT450D (Freq: 406-512 MHz Dipole Antenna / Off- Air)
5. PCTEL - BMOY4705 (470-512 MHz 9dBd 5 Element Yagi Antenna/ Off-Air)
6. Or approved equal.

B. Ratings:
1. Impedance: 50 ohms.
2. Frequency Range: 490 MHz / 800 MHz

2.5 OFF-THE-AIR RADIO REPEATER SYSTEM COMPONENTS FOR DAS

A. The nature of the Off-The-Air Radio Repeater Systems mandate custom- designed and fabricated components tailored around the required operating frequencies. Detailed specifications shall be provided for each custom-designed component for approval prior to fabrication.
Manufacturers:
1. Axell Wireless BDA: 50-206801
2. Andrew/Commscope BDA: Node A4
3. Or approved equal

B. The coaxial cables, radiating cables, and/or fixed antennas selected for use in this system shall be submitted for approval prior to procurement. The cables shall be rated Low-Smoke, Halogen-Free (LSHF)

C. The Off-The-Air Radio Repeater Systems shall be provided with a backup power system that will assure the system will continue to provide service during interruptions of commercial power to the system lasting up to 8-hours

D. Ratings:
1. Impedance: 50 ohms.
2. Frequency:

TDR Channel No.	Band	Tx Channels (MHz)	Rx Channels (MHz)
1	LB	490.8625	493.8625
2	LB	490.7875	493.7875
3	HB	496.4375	499.4375
4	HB	496.5375	499.5375
5	HB	496.6125	499.6125
6	HB	496.5625	499.5625
7	HB	496.4875	499.4875
8	HB	496.3375	499.3375
9	LB	490.9625	493.9625
10	LB	490.9125	493.9125
11	LB	490.8875	493.8875
12	LB	490.8375	493.8375
13	LB	489.5375	492.5375

14	LB	489.5125	492.5125
15	HB	496.5875	499.5875
AVL 1	HB	496.4625	499.4625
AVL 2	LB	489.0875	492.0875
AVL 3	LB	489.1625	492.1625
AVL 4	LB	490.7625	493.7625
MTPD	LB	490.9375	493.9375
SMNT	HB	496.5125	499.5125

PART 3 - EXECUTION

3.1 INSTALLATION

A. End-Of-Line Terminal Supervisor's Office / Rail Yard Tower Office / Gate House
   1. Install the End-Of-Line Terminal Supervisor's Mobile Radio / Rail Yard Tower Radio and Gate House Radio, as shown on the contract drawings, in a location approved by the Engineer.
   2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle at the different locations.
   3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

B. The WMATA Distributed Antenna System (DAS
   1. Install the Metrorail CRCS Radio Subsystem, as shown on the contract drawings, in a location approved by the Engineer.
   2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle at the different locations.
   3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

3.2 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions as specified in the contract documents.

B. Supervise final wiring connections and system adjustments.

3.3 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

3.4 TEST

A. All End-Of-Line Terminal Supervisor's Radio, Yard Tower Radios and Gate house radios shall be tested for 2-way communication. For measuring the audio quality of the communications during the RF coverage tests, the Delivered Audio Quality (DAQ) levels from ANSI/TIA Technical Service Bulletin (TSB)-88 were used. A DAQ of 3.4 or better is expected

B. All Distributed Antenna Systems (DAS) installed in stations and other WMATA facilities to provide supplemental coverage shall be tested for 2-way communication and maintain a signal level exceeding -95 dBm for 95% of the time in the entire station and provide Delivered Audio Quality rating of 3.4 (DAQ 3.4) or better in all

areas specified in this document . Open areas shall be divided up into 5 feet x 5 feet grids. Radio checks and downlink control channel levels will be measured in each grid. Two or more radio check failures after moving 3 feet in either direction within a grid will be considered a failure. Radio coverage shall also be performed in all station public areas, service rooms and other non-public areas that are part of the station or facility as defined in drawings.

C. Test Requirement for DAQ (3.4 and better) :

DAQ 5.0	Speech easily understood.
DAQ 4.5	Speech easily understood. Infrequent noise/distortion.
DAQ 4.0	Speech easily understood. Occasional noise/distortion.
DAQ 3.4	**Speech understandable with repetition only rarely required. Some noise/distortion.**

3.5 DEMONSTRATION

A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

F. Demonstrate system operation.

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

SECTION 16820

COMMUNICATIONS - PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

A. Public Address Systems are used to provide information to the public in passenger stations and trains. Public Address Systems are also used to communicate with personnel in station service rooms, yards and shops. Separate public address systems shall be provided at each passenger station, on board each train, in yards, and in shops.

B. Access to each Public Address System shall be provided to a local control station on an individual basis and to the Operations Control Center on an individual select, group select, or "all call" select condition control.

C. Transit vehicle public address systems allow for public announcements by the train operator. Also, through intervention by the train operator, public announcements can be made directly from the Operations Control Center.

D. The Rail Operations Control Center (OCC) in the Jackson Graham Building uses the PENTA PA Control Equipment to select and broadcast in the following ways:
1. Systemwide announcements to all Metro Rail Stations.
2. Announcements to selected Lines (i.e., Red Line, Green Line, or Blue/Orange Lines).
3. Individual passenger stations.

E. Each passenger station in the WMATA Rail System shall be designed to have an independent Public Address (PA) system. The passenger station PA system provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the kiosk, the Rail Operations Control Center (OCC) in the Jackson Graham Building, Automatic Public Address Announcement System (APAAS), and end-of-line station's dispatcher's room.

F. A line mixer shall be used to control the level of these individual inputs. A single output shall be taken from the mixer and applied to a compressor-limiter, the output of the compressor-limiter is fed to the APAAS control unit through the APAAS/PA interface unit (described below) to the final power amplification.

G. The PA system shall provide noise compensated circuits to the platform and mezzanine areas, where train noise must be overcome by automatically adjusting the PA volume.

H. Non-noise compensated circuits shall be provided for service rooms and non-revenue passageways, these areas normally do not require noise compensation.

I. The PA system design shall be such that announcements that are made over the PA system will be managed in accordance with the following access priority:
1. Automatic Public Address Announcement System.
2. Rail Operations Control Center (OCC) in the Jackson Graham Building.
3. Kiosk.
4. When an announcement of a higher priority is initiated, the lower priority announcement is removed from the amplifier's input until the high priority announcement is completed.

J. The operation of the passenger station PA system from the kiosk is accomplished by simultaneously depressing the push-to-talk pushbuttons on the hand-held microphone and the kiosk PA Control Panel, then speaking into the hand-held microphone. Certain kiosks (generally those subject to “large event” traffic) shall be designed to have a portable wireless microphone transmitter, to be worn by the kiosk attendant, and a diversity wireless receiver. The diversity wireless receiver is connected to the PA system so as to by-pass and take the place of the normal kiosk microphone when the wireless microphone is keyed. This feature is used to allow the kiosk attendant freedom of movement beyond the kiosk for various reasons including crowd control.

K. When a selection is made by a Passenger Operations Supervisor in the Rail OCC, the audio path of the console is connected to the PA system channel of the selected passenger station's Carrier Transmission System terminal for transmission to the selected passenger station(s). At the passenger station, the audio path from the assigned PA system channel of the Carrier Transmission System is connected to the station PA Control Unit.

L. The Dispatcher's PA Control Panel shall function in an identical manner as the kiosk Public Address Control Panel. (Loudspeaker zone selection is not available at the kiosk).

M. The PA system’s design shall have redundant power amplifiers. The power amplifiers shall be connected to the Amplifier Supervisory Control Unit. One power amplifier shall be connected to the "MAIN CHANNEL" of the Amplifier Supervisory Control Unit, and the second power amplifier shall be connected to the "auxiliary channel" of the Amplifier Supervisory Control Unit. Each Amplifier Supervisory Control Unit shall monitor the associated power amplifiers and, upon sensing a malfunction of the "main channel" power amplifier, shall automatically transfer the audio path to the "auxiliary channel" power amplifier.

N. The passenger station PA speakers shall be designed to be wired in either noise-compensated or non-noise compensated circuits. Noise-compensated circuits shall be used in areas where train noise must be overcome by automatically adjusting the PA volume. The station mezzanine area and platform areas are of noise compensated circuits, which use Automatic Level Control. For areas where noise compensation is required, circuits shall be wired to the Loudspeaker Distribution Panel designated for noise-compensated circuits. Non-noise compensated circuits shall be used in all other areas. In areas where noise-compensated circuits are not required, circuits shall be wired to the Loudspeaker Distribution Panel designated for non-noise compensated circuits. Passenger station service rooms and non-revenue passageways are examples of areas that require non-noise compensated speaker circuits.

O. Each kiosk in the WMATA Rail System shall be designed to have an Attendant/Passenger Interphone System. The Attendant/Passenger Interphone System shall provide for communication between passengers and the kiosk attendant at the kiosk. The Attendant/Passenger Interphone System shall serve both the “PAID” and the “UNPAID” side of each kiosk.

P. A sufficient quantity of speakers shall be placed in passenger stations to give even volume distribution without objectionable loudness from any one speaker location.

Q. The PA amplifiers shall have a constant voltage output of 70.7 volts. Each loudspeaker shall be equipped with an audio transformer to match the 70.7-volt line with the loudspeaker. The transformers shall have various taps to allow for adjustment of the sound

level in a particular area. Each transformer shall have a minimum of four taps. The power rating for each of the taps shall be determined during installation.

R. Design of public address systems in stations shall be coordinated with architectural design.

1.02 SECTION INCLUDES

A. Loudspeakers in the passenger station and services areas.

B. Control hardware in the Kiosk and End-Of-Line dispatcher office.

C. Control and amplification equipment in the Communication Equipment Room.

D. Wireless Microphone System in the Kiosk.

E. Attendant/Passenger Interphone System in the Kiosk.

F. Intercom System in the End-Of-Line dispatcher office.

1.03 UNIT PRICES

A. Unit Prices include all equipment racks, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, all the connections and cross-connections required for a complete operational installation of the Public Address System and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.04 RELATED SECTIONS

A. Section 16705 - Communications Standard Specifications - Equipment & Materials.

B. Section 16706 - Communications System Submittals & Services.

C. Section 16707 - Communications Systems Quality Assurance & Testing

D. Section 16710 -Communications Grounding.

E. Section 16715 - Communications Electrical Power Distribution.

F. Section 16733 - Communications - Kiosk Systems

G. Section 16771 – Communications Carrier Transmission System.

1.05 REFERENCES

A. National Electric Code (NEC).

B. UL Standard 1480, Speakers for Fire Protective Signaling Systems.

1.06 SYSTEM DESCRIPTION

A. Description: Provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the kiosk, the Rail

OCC in the Jackson Graham Building, Automatic Public Address Announcement System (APAAS), or end-of-line station's dispatcher's room.

B. The Attendant/Passenger Interphone System provides for communications between passengers and the Station Manager at the kiosk. The Attendant/Passenger Interphone System services both the "PAID" and the "UNPAID" side of the kiosk.

C. The dispatcher PA System/Intercom, in end-of-line stations, shall provide access to the passenger station PA system to make announcements to the station platform and mezzanine at any time that the PA system is not already in use. Additionally, a separate intercom system shall be provided at the dispatcher's room in end-of-line stations to provide oral communications between the Train Control Room, the Dispatcher's Room, and the Operations Room.

D. Capacity:

1. The Contractor shall design the placement of Type 1 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package
2. The Contractor shall design the placement of Type 2 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
3. The Contractor shall design the placement of Type 3 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
4. The Contractor shall furnish and install a kiosk PA Control Panel(s) constructed in accordance with contract specifications and drawings.
5. The Contractor shall furnish and install a station PA Control Unit(s) constructed in accordance with contract specifications and drawings.
6. The contractor shall furnish, and install a kiosk Attendant/Passenger Interphone(s) in accordance with contract specifications and drawings.
7. The contractor shall furnish, and install a voice Pre-Amp/Processor in accordance with contract specifications and drawings.
8. The contractor shall furnish, and install a Dual Zone Priority Mixer in accordance with contract specifications and drawings.
9. The Contractor shall furnish, and install a Compressor/Limiter in accordance with Contract Specifications and Drawings.
10. The Contractor shall furnish, and install a Audio Distribution Amplifier in accordance with Contract Specifications and Drawings.
11. The Contractor shall furnish, and install a Ambient Noise Sensor in accordance with Contract Specifications and Drawings.
12. The Contractor shall furnish, and install a Digital Equalizer in accordance with Contract Specifications and Drawings.
13. The Contractor shall furnish, and install a 60-Watt Power Amplifier in accordance with Contract Specifications and Drawings.
14. The Contractor shall furnish, and install a 120-Watt Power Amplifier in accordance with Contract Specifications and Drawings.
15. The Contractor shall furnish, and install a Wireless Microphone Transmitter and Receiver in accordance with Contract Specifications and Drawings.
16. The Contractor shall furnish, and install a 24-Vdc Power Supply in accordance with Contract Specifications and Drawings.
17. The Contractor shall design, furnish, and install a custom Loudspeaker Distribution Panel in accordance with Contract Specifications and Drawings.
18. The Contractor shall design, furnish, and install a custom Audio and Control Distribution Panel in accordance with Contract Specifications and Drawings.

19. The Contractor shall design, furnish, and install a custom Loudspeaker Zone Attenuator Assembly in accordance with Contract Specifications and Drawings.
20. The Contractor shall furnish, and install a PA Patch Panel Assembly in accordance with Contract Specifications and Drawings.
21. The Contractor shall furnish, and install a End-Of-Line Dispatcher Intercom in accordance with Contract Specifications and Drawings.

1.07 SYSTEM PERFORMANCE REQUIREMENTS

A. The contractor shall be responsible for the overall performance of the PA system. The following overall system performance requirements are designed to ensure that the PA system, delivered under these specifications, meets the performance requirements of the Washington Metropolitan Area Transit Authority.
1. PA Overall Frequency Response: ±5db or better 200-Hz to 8,000-Hz
2. PA Sound Pressure Levels: 100dB minimum measured 1 meter from front of each speaker.
3. PA Overall Harmonic Distortion: Less than 1% 200-Hz to 8,000-Hz.
4. Interphone Overall Frequency Response: ±5db or better 200-Hz to 5,000-Hz
5. Interphone Sound Pressure Levels: 90dB minimum measured 1 meter from kiosk wall, 1.5 meters above floor.
6. Interphone Overall Harmonic Distortion: Less than 5% 200-Hz to 5,500-Hz.

1.08 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.

C. Product Data: Provide showing electrical characteristics and connection requirements for each component.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.09 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

C. Installer: Service facilities within 50 miles of Project.

1.10 MAINTENANCE SERVICE

A. Furnish service and maintenance of Public Address System until Final Completion.

PART 2 - PRODUCTS

2.01 SPEAKERS ASSEMBLY TYPE 1 (PYLON) and TYPE 2 (CEILING)

A. Manufacturers:
   1. QUAM Model 8C10PAOTB/TBL70(Driver) W/Quam-Nichols SE1WVP (Enclosure Type 1) w/Quam-Nichols BS8WVP (Grill Type 1) (or approved equal).

B. Description: Speakers for use in Pylons and Passenger Station ceiling.

C. Ratings:
   1. Magnet:
      a. Weight: 10-ounces.
      b. Material: Ceramic.
      c. Flux Density: 9K gauss.
      d. DC Resistance: 7.4 ohms.
      e. Diameter: One inch.
   2. Electrical:
      a. Power Handling: 15-Watts.
      b. Transformer: 70-volt multi-tap at 4,2,1,and .5watts.
      c. Frequency Response: 80-Hz to 8-KHz.
      d. Sensitivity: 95db.
   3. Mechanical:
      a. Depth: 3-1/4 inches.
      b. Transformer Mounting: Min 2 inches – Max 2-13/16 inches.
      c. Mounting Hole Circle: 7-5/8 inches.
      d. Baffle Opening: Seven inches.
      e. Cone: 8-inch full range moisture proof.
      f. Grill: Custom finish color to match current WMATA pylon color.

2.02 SPEAKERS ASSEMBLY TYPE 3 (STAFF SERVICE AREAS)

A. Manufacturers:
   1. Atlas/Soundolier Model No. VT-27UCN (or approved equal)

B. Description: Speakers for use in service areas.

C. Ratings:
   1. Transformer: 70.7-Volts.
   2. Power Taps: 1 and 2 Watts
   3. Frequency Response: 600-Hz to 5500-Hz (± 5db).
   4. Sensitivity: 96.9dB (1-watt at 1-meter).
   5. Dimensions: 4-1/2 inches, square.
   6. Mounting Box: Atlas/Soundolier Model No. SEN.
   7. Color: Neutral Gray.
   8. Construction: Die-cast zinc, water/moisture sealed.

2.03 KIOSK PA CONTROL PANEL

A. Manufacturers:
   1. Custom Item.

B. Description: Station Manager's Public Address System Control Panel.

C. Furnished by WMATA. [IS THIS STILL APPLICABLE?]

2.04 STATION PA CONTROL UNIT

A. Manufacturers:
   1. Custom Item.

B. Description: Control and interface unit for the PA System.

C. Furnished by WMATA.[IS THIS STILL APPLICABLE?]

2.05 KIOSK ATTENDANT/PASSENGER INTERPHONE

A. Manufacturers:
   1. Norcon Communications Model No. TTU-7J electronic communications system (Norcon Communications, Inc., 516-239-0300 or www.norconcomm.com) (or approved equal).

B. Description: Intercom between Kiosk attendant and passengers.

C. Ratings:
   1. Audio Power: Two watts.
   2. Microphone: Removable Gooseneck.
   3. Power: 12-Vdc battery pack.
   4. Speaker Enclosure Finish: Metro Bronze, Federal Standard 595B, Color No. 20040.

2.06 VOICE PRE-AMP/PROCESSOR

A. Manufacturers:
   1. Symetrix Model No. 572E (or approved equal) with Middle Atlantic Product SC-1 security cover (or approved equal).

B. Description: Voice processor incorporating a high-quality microphone preamp coupled to three-band parametric equalizer, high and low pass filters, and a dynamic range processor

C. Ratings:
   1. Mic Input:
      a. Impedance: Balanced transformerless, low impedance..
      b. Gain Range: 20 to +60 dB(pad out), 5 to 45 dB (pad in).
      c. Max Input Level: 0 dBu (pad out).
      d. Phantom Power: +48 Volts nominal
   2. Line Input:
      a. Impedance: 10k ohms transformerless, balanced bridging.
      b. Max Input Level: +20dBu.
   3. Parametric Equalizer:
      a. Frequency: Low: 16-Hz to 500-Hz, Mid: 160-Hz to 6300-Hz, High: 680-Hz to 22-KHz.
      b. Peak/Dip Bandwidth: 0.3 octaves, measured at maximum boost.
      c. Maximum Boost/Cut: ± 15dB.
   4. Filters:
      a. Low Cut Filter Slope: 12dB/octave.
      b. Low Cutoff Frequency Range: 6-Hz to 260-Hz @ - 3dB.
      c. High Cut Filter Slope: 12dB/octave.
      d. High Cutoff Frequency Range: 3-KHz to 65-KHz.
   5. Metering:
      a. Type: Multi-segment LED bar graph.
      b. Output Level: -20, -10, 0, Clip (0 VU=+4dBu), VU calibrated, peak responding.
      c. Expander Gain Reduction: 3, 6, 12, 20 dB.
      d. Compressor Gain Reduction: 3, 6, 12 dB.
   6. Dynamic Range Processor:
      a. Type: Interactive comp/limiter-downward expander.

b. Comp/Limiter Ratio: 1:1 to 10:1.
c. Downward Expansion ratio (mix): 1:1.8.

7. Output:
   a. Output section Type: Balanced transformerless.
   b. Maximum Output Level: +21dBu balanced.
   c. Output Clip LED: Fires 3dB below clipping.
   d. Output source Impedance: 200-Ohms, Balanced.
   e. Output Gain: ± 15dB.
8. Frequency Response: 20-Hz to 20-KHz.
9. Power Input: 120-Vac.
10. Mounting: 19" rack.

2.07 DUAL ZONE PRIORITY MIXER

A. Manufacturers:
   1. Symetrix, Inc. Model 450 (or approved equal).

B. Description: Mixer with three levels of priority .

C. Ratings:
   1. Microphone inputs: Two, low impedance, balanced.
   2. Microphone Common Mode Rejection: >85dB @ 1KHz, 1 Volt RMS.
   3. Line Inputs: Four, stereo.
   4. Line Input Impedance: > 10K ohms, balanced.
   5. Line Common Mode Rejection: >40dB @ 1KHz, 1 Volt RMS.
   6. Line Input Level: +24dBu balanced, +18dBu unbalanced maximum.
   7. Frequency Response: ±1 dB, 20-Hz to 20-KHz any input to any output.
   8. Mounting: 19-inch rack.
   9. Power Input: 120-Vac.

2.08 COMPRESSOR/LIMITER

A. Manufacturers:
   1. Symetrix, Inc. Model 301 (or approved equal).

B. Description: AGC-Leveler with mic/line input.

C. Ratings:
   1. Line Inputs: 20k ohms balance, 10k ohms.
   2. Microphone Input: XLR-female & Screw Terminals.
   3. Outputs: XLR-male & Screw Terminals 200 ohms balanced.
   4. Attack Time: 500µS to 100 mS.
   5. Release Time: 50mS to 4 seconds.
   6. Threshold: –40dBu to +20dBu..
   7. Compressor Ratio: Bypass to 10:1.
   8. Power Input: 120-Vac, 7-pin DIN.
   9. Mounting: 19-inch rack.

2.09 AUDIO DISTRIBUTION AMPLIFIER

A. Manufacturers:
   1. Symetrix, Inc. Model 301 (or approved equal).

B. Description: One input/four output audio distribution amplifier.

C. Ratings:
1. Maximum Input Level: +26dBu Balanced
2. Maximum Output Level: +26dBu Balanced (20k ohm load), +22dBm (600 ohm load).
3. Input Impedance: 20k ohms balanced, 10k ohms unbalanced.
4. Output Impedance: 200 ohms balanced, 100 ohms unbalanced.
5. Frequency Response: ± 0.5dBm, 20-Hz to 20-KHz.
6. Input Gain Range: ± 15dB.
7. Output Gain Range: 0 to –20dB.

2.10 AMBIENT NOISE SENSOR

A. Manufacturers:
1. Symetrix Model No 571 (or approved equal)

B. Description: Ambient sensing automatic level controlling device to regulate the operating level of a sound system in proportion to changing noise levels in the sound system's operating area.

C. Ratings:
1. Inputs: Two sensing mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one paging mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one line (0dBu nominal) CMRR =< 40dB at 1-KHz, one music (-10dBu nominal) CMRR =< 40dB at 1-KHz
2. Maximum Input Level: -30dBu (mic inputs), +18 (line inputs).
3. Input Impedance: Mic: electronically balanced bridging 200 ohms, nominal (not phantom powered). Line: electronically balanced bridging 20 kilo ohms nominal.
4. Phantom Power (on all mic inputs): 15-Vdc.
5. Output: Balanced, transformerless.
6. Output Impedance: 100 ohms.
7. Maximum Control Range: 40dB.
8. Ambient noise to Gain Ratio: Variable, 2:1 to 1:2.
9. Averaging Time: 1.2 sec. To 5 min.
10. Page-Over Music (ducking): Variable, 0 to 14 dB.
11. Frequency Response: 20-Hz to 20-KHZ(+ 1 dB,-0 dB).
12. Power Input: 120-Vac 60-Hz.
13. Mounting: 19-inch rack.

2.11 DIGITAL EQUALIZER

A. Manufacturers:
1. Shure Model No. DFR-11EQ (or approved equal).

B. Description: Digital 1/3 Octave graphic equalizer, automatic and manual acoustic feedback suppression for 10 frequencies, digital delay compressor/limiter..

C. Ratings:
1. Remote Programming: RS232C serial port.
2. Frequency Response: 20-Hz to 20-KHz ± 1.0dB reference 1 KHz.
3. Dynamic Range: 104db minimum, A-weighted, 20-Hz to 20-KHz.
4. Sampling Rate: 48-KHz.
5. Digital-to-Analog, Analog-to-digital Conversion: 20-bit resolution.
6. Voltage Gain:
   a. Power Off: -1 dB ± 1dB.

b. Equal Input And Output Sensitivities: 0dB ± 2dB.
c. Input –10dBv, Output +4dBu: 12dB ± 2dB.
d. Input +4dBu, Output – 10dBv: -12dB ± 2dB.

7. LED Signal Indicators: Clip: 6dB down from input clipping.
8. Feedback Filters:
   a. Ten 1/10-octave adaptive notch filters from 60-Hz to 20-KHz.
   b. Deployed to 1-Hz resolution of feedback frequency
   c. Deployed in depths of 3dB, 6dB, 9dB, 12dB and 18dB (12.5 Low Q in graphic EQ mode) attenuation.
   d. Filter shape variable between HI Q and LOW Q.
9. Graphic Equalizer:
   a. Frequency Bands: 30 bands on ISO, 1/3-octave centers.
   b. Filter Type: 1/3- octave, constant Q.
   c. Maximum Boost: 6dB per band.
   d. Maximum Cut: 12dB per band, high- and low-pass filters, 12dB/octave nominal.
10. Parametric Equalizer:
   a. Frequency Bands: 10 bands, variable frequency, variable Q.
   b. Boost/Cut Range: + 6 to –18 dB per band.
   c. Q Range: 1/40-octave to 2 octave.
   d. Shelf/Rolloff Filters: Shelf, + 6 to – 18 dB per filter. Rolloff, 6dB, 12dB, 18dB, or 24dB per octave nominal.
11. Delay: Up to 1300ms.
12. Limiter:
   a. Threshold: – 60dBFs to – 0.5dBFs, 0.5dB resolution
   b. Attack: 1 ms to 200 ms.
   c. Decay: 50 ms to 100 ms.
   d. Ratio: 4 to 1.
13. Mounting: 19-inch rack.
14. Power Input: 120-Vac 60-Hz.

2.12 6O-WATT POWER AMPLIFIER

A. Manufacturers:
   1. TOA Model No. P-906MK2 with MB 35B rack mount kit (or approved equal).

B. Description: Audio power amplifier.

C. Ratings:
   1. Output Power: 60-watts RMS.
   2. Frequency Response: 20-20,000 Hz, +1dB/-3 dB.
   3. Inputs: One input port, one direct.
   4. Input Sensitivity/Impedance:
      a. Input Port: 100 mV or 1000 mV (switchable)/10 K ohms.
      b. Direct Input: 100 mV or 1000 mV (switchable)/10 K ohms.
   5. Output:
      a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
      b. Main(Direct): 4 ohms, unbalanced.
   6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
   7. Power Input: 120-Vac 60-Hz, 100-watts.
   8. Mounting: 19-inch rack, maximum of two EIA rack units in height.
   9. Input Module: TOA Model No. B01F balanced line input, 10k ohms.

2.13 12O-WATT POWER AMPLIFIER

A. Manufacturers:
   1. TOA Model No. P-912MK2 with MB 35B rack mount kit (or approved equal)

B. Description: Audio power amplifier.

C. Ratings:
   1. Output Power: 120-watts RMS
   2. Frequency Response: 20-20,000 Hz, +1dB/-3dB.
   3. Inputs: One input port, one direct.
   4. Input Sensitivity/Impedance:
      a. Input Port: 100 mV or 1000 mV (switchable)/10 K ohms.
      b. Direct Input: 100 mV or 1000 mV (switchable)/10 K ohms.
   5. Output:
      a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
      b. Main(Direct): 4 ohms, unbalanced.
   6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
   7. Power Input: 120-Vac 60-Hz, 180-watts.
   8. Mounting: 19-inch rack, maximum of two EIA rack units in height.
   9. Input Module: TOA Model No. B01F balanced line input, 10k ohms.

2.14 WIRELESS MICROPHONE TRANSMITTER AND RECEIVER

A. Manufacturers:
   1. Shure Model No. UC2/UC4 UHF microphone system with UA500 remote antenna kit and PS40 Power Supply (or approved equal).

B. Description: UHF Wireless Microphone System with head-worn microphone transmitter.

C. Ratings:
   1. RF Carrier Frequency Range: 782 – 806 MHz.
   2. Working Range 500 ft. minimum under typical conditions.
   3. Audio Frequency response: 45 to 15,000 Hz ±2dB.
   4. Gain Adjustment Range: -6 to 26 dB.
   5. Receiver Audio Output Level (Maximum):
      a. Unbalanced: + 5dBu typical.
      b. Balanced: + 14dBu typical.
   6. RF Sensitivity: -108dBm at 12dB SINAD.
   7. Image Rejection 90dB typical.
   8. Spurious Rejection 70dB typical.
   9. Power Requirements:
      a. UC2: 9V alkaline battery.
      b. UC4: 15-Vdc, 600-mA.
   10. Mounting: 19 rack

2.15 24-VDC POWER SUPPLY

A. Manufacturers:
   1. Acopian, Model No. 24PT10 (or approved equal).

B. Ratings:
   1. Nominal Voltage: 24-Vdc (regulated).
   2. Rated Current: Three Amperes continuous (minimum).
   3. Regulation: Less than 2%.

4. Ripple: Less than 10 mV rms.
5. Power Required: 105 to 125 Vac, 50/60 Hz, 170-watts (nominal).

2.16 LOUDSPEAKER DISTRIBUTION PANEL

A. Manufacturers:
1. Custom assembly by contractor.

B. Metal EIA rack mount panel:
1. Middle Atlantic Products Rack Panel- PHBL Series or approved equal.

C. Phoenix Captive Wire Terminal Block product or approved equal.

D. Captive wire terminal blocks rated for not less than 120-Vac, 15-amp.

E. Provide sufficient quantity of captive wire terminal blocks to support all loudspeaker zone cabling plus 10% spare terminations for expansion.

F. Printed permanently affixed labeling strip identifying each numbered captive wire terminal.

G. Provide all mounting hardware and cable terminations for a complete assembly.

2.17 AUDIO AND CONTROL DISTRIBUTION PANEL

A. Manufacturers:
1. Custom assembly by contractor.

B. Metal EIA rack mount panel:
1. Middle Atlantic Products Rack Panel- PHBL Series or approved equal.

C. Phoenix Captive Wire Terminal Block product or approved equal.

D. Captive wire terminal blocks rated for not less than 120-Vac, 15-amp.

E. Provide sufficient quantity of captive wire terminal blocks to support all loudspeaker zone cabling plus 10% spare terminations for expansion.

F. Printed permanently affixed labeling strip identifying each numbered captive wire terminal.

G. Provide all mounting hardware and cable terminations for a complete assembly.

2.18 LOUDSPEAKER ZONE ATTENUATOR ASSEMBLY

A. Manufacturers:
1. Custom assembly by Contractor.

B. Description: Volume control of Staff Service Area loudspeaker zones.

C. Metal EIA Rack Mount Panel:

1. Middle Atlantic Products Rack Panel – PHBL series or approved equal.

D. 70-volt Loudspeaker attenuators:

1. Atlas-Soundolier AT-10RM or AT35RM attenuator or approved equal (actual model/wattage rating determined must exceed actual load of loudspeaker zone connected).
2. With front panel knobs.
3. Attenuation steps of 3dB.
4. Non-shorting rotary switch.
5. Ten steps, plus off position.
6. Silver plated contacts.
7. One attenuator per loudspeaker circuit.

E. Custom engraving (or silk screening) identifying panel as STAFF SERVICE AREA LOUDSPEAKER ZONES @, .25-in. tall letters.

F. Custom engraving (or silk screening) identifying each loudspeaker zone for each attenuator .375-inch tall letters.

G. Rear mounted loudspeaker cabling captive wire terminal strip.

H. Provide all mounting hardware and cable terminations for a complete assembly

2.19 PA PATCH PANEL ASSEMBLY

A. Manufacturers:
1. AVR Communications Group VERSAPATCH Model No. II-AB (or approved equal).

B. Description: Patch panel assembly for the audio power amplifiers and audio signal

C. Ratings
1. Number of Jacks: Two rows of 24
2. Insertion Loss: Less than 0.1dB
3. Jack Circuits Configuration: Top-to-bottom row jack circuits are normalled (looped) internally (AB).
4. Punch Block: Rear mounted proprietary 66-terminal punch block for solid and stranded wire (Flexiblock)
5. Chassis and Brackets: Aluminum
6. Mounting: 19-inch rack.
7. Compatibility: Standard ¼ inch 3-conductor phone shielded audio patch cords.

D. Provide printed designation labeling for each jack.

E. Sealed enclosure to keep out contaminants.

F. Rear Cable strain relief bar.

G. Provide sufficient quantity of normalled patch circuits to patch the combined total of all individual patch points

2.20 PATCH PANEL PUNCH TOOL

A. Manufacturers:
1. AVR Communications Group Model No. S-714 (or approved equal).

B. Compatible with wiring punchblocks included with patch panel.

C. Contractor shall locate/ Punch Tool in rack mounted storage drawer for use by WMATA Maintenance.

2.21 PATCH PANEL PUNCH TOOL

A. Manufacturers:
   1. AVR Communications Group Model No. 639-100-085 (or approved equal).

B. Description: Audio patch cord compatible mating with provided Patch Panels..

C. Ratings:
   1. Plugs: TSR ¼ inch phone connectors.
   2. Length: 60 inches.
   3. Cable: 22-gauge stranded twisted pair, with shield and overall insulator.

D. Locate/store Patch Cord in rack mounted storage drawer for use by WMATA Maintenance.

2.22 END-OF-LINE DISPATCHER INTERCOM

A. Manufacturers:
   1. Aiphone Communication Systems Model No. LEF-3 (or approved equal).

B. Description: An open voice, selective calling type intercom with individual selector switches for each station.

C. Ratings:
   1. Output: 800 mW @ 20 ohms (reception), 500 mW @ 20 ohms (transmission).
   2. Communication: Press-to-talk, release-to-listen at master station. Hands free response.
   3. Capacity: Up to four stations, intermixable.
   4. Speaker Sensitivity: 40dB.
   5. Total Harmonic Distortion: Less than 5% at rated output power.
   6. Signal to Noise Ratio: 60dB.
   7. Frequency Response: -3dB, 770-6,800 Hz.
   8. Power Source: 12-Vdc, 300-mA per station (Use Aiphone PS-12C power supply).

2.23 INTERCOM POWER SUPPLY

A. Manufacturers:
   1. Aiphone Communication Systems Model No. PS-1C (or approved equal).

B. Description: DC power supply for Aiphone LEF-3 intercom.

C. Ratings:
   1. Input Voltage: 120-Vac, 50/60 Hz.
   2. Power Consumption: 28 watts.
   3. Output Voltage: 12-Vdc.
   4. Maximum Output Current: One Amp dc.

2.24 INTERCOM SUB STATION

A. Manufacturers:
   1. Aiphone Communication Systems Model No. LS-NVP with SBX-NVP surface mount box (or approved equal).

B. Description: Vandal proof sub station for Aiphone LEF-3 intercom.

C. Ratings:
1. Speaker: 20 ohms, three-inch diameter, water and puncture resistant, 2.5 oz. Ceramic magnet.
2. Call Button: SPST with mechanical stop, normally open.
3. Faceplate: 11-gauge carbon steel with powder-coated white baked epoxy finish.
4. Communication: Hands free at sub. Master station controls push-to-talk, release-to-listen.
5. Mounting: Surface mount with SBX-NVP box.
6. Mounting Hardware: Tamper-proof screws
7. Dimensions: SBX-NVP 8-5/8"H x 6-5/8"W x 2-1/4"D.
8. Power Source: Supplied by master.

2.25 CARDIOD DYNAMIC MICROPHONE WITH 18" GOOSENECK

A. Manufacturers:
1. Shure SM57 (microphone) with Shure A12 (mounting flange), with Shure G18-CN(18" Gooseneck), with Shure A2WS (windscreen) (or approved equal).

B. Description: Kiosk microphone.

C. Ratings:
1. Type: Unidirectional Dynamic Cardioid.
2. Impedance: 150 ohm (310 actual).
3. Frequency Response: 40-15 KHz.
4. Output: Balanced 3-pin male XLR.

2.26 AC POWER LINE CONDITIONER-20 AMP

A. Manufacturers:
1. New Frontier Electronics Surge-X SX2120 (or approved equal).

B. Description: Electrical power line surge suppressor and line conditioner.

C. Ratings:
1. Mounting: 19-inch rack.
2. Current: 20 amps at 120-Vac.
3. Rear Outlets: 12 switched, two un-switched.
4. Front Panel Indications: Electrical service and surge fault.
5. Front Panel Switches: One for switched outlets.

D. Automatic internal test of circuitry.

E. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.

F. Series mode circuitry rated to immediately clamp 6000-Vac line surges.

G. Series mode circuitry rated with unlimited surge current without ground contamination.

2.27 AC POWER LINE CONDITIONER, 15-AMP

A. Manufacturers:

1. New Frontier Electronics Surge-X SX115R (or approved equal).

B. Description: Electrical power line surge suppressor and line conditioner.

C. Ratings:
1. Mounting: 19-inch rack.
2. Current: 15-amps at 120-Vac.
3. Rear Outlets: Six switched, two un-switched.
4. Front Panel Indications: Electrical service and surge fault.
5. Front Panel Switches: One for switched outlets.

D. Automatic internal test of circuitry.

E. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.

F. Series mode circuitry rated to immediately clamp 6000-Vac line surges.

G. Series mode circuitry rated with unlimited surge current without ground contamination.

2.28 SHIELDED TWISTED-PAIR CABLE (16-AWG)

A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 60 watts.

B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

C. Ratings:
1. Conductors: 16-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

2.29 SHIELDED TWISTED-PAIR CABLE (14-AWG)

A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 120 watts.

B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

C. Ratings:
1. Conductors: 14-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

2.30 SHIELDED MULTI-TWISTED-PAIR CABLE (20-AWG)

A. Description: Audio cable for all audio wiring and ambient noise and paging microphones.

B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

C. Ratings
1. Conductors: 20-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

2.31 SHIELDED MULTI-TWISTED-PAIR CONTROL SIGNALING/AUDIO CABLE

A. Description: control signaling multi-pair cable type, for all control and DC voltage wiring.

B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

C. Ratings:
1. Conductors: 18-AWG stranded twisted pairs ASTM tinned copper with overall 100% foil shield.

2.32 AMBIENT NOISE SENSOR MICROPHONE (ANS-MIC)

A. Manufacturers:
1. Crown Model No.PZM-11 or approved equal.

B. Ambient Noise Sensor Microphone, phantom powered boundary microphone mounted on single-gang wallplate.

C. Color white.

D. Ceiling mounted at locations shown on drawings, in metal junction box provided by Contractor.

E. Hemispherical polar pattern.

F. Electret condenser element.

G. Frequency response 80Hz to 20,000Hz.

H. Signal to noise ratio 68dB at 94dB SPL.

I. 225 ohms balanced impedance.

J. Provide with mounting hardware, conduit pathway and cabling.

2.33 DISPATCHER PA FACILITY-TABLETOP INSTRUMENT CABINET

A. Manufacturers:
1. AMCO Engineering Company, Model No. IAPDM21-19-18-PT (or approved equal).

B. 19-inch vertical rack mounting channels.

C. Vinyl covered aluminum construction, rubber base feet, convection cooling.

D. Dimensions (D, W, H): 18 3/4" x 19" x 21".

E. Color: Light Blue.

PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Install a complete and operational passenger station Public Address System, as described herein, in the passenger station(s). This includes installations in the Kiosk(s), Communications Equipment Room(s) and Dispatcher's Facility.

B. Install all terminals, hardware, wiring and cabling, conduits, and fittings. The Contractor shall install the required connectors, attenuators, baluns, audio isolation transformers, and inter-rack wiring between the various equipment, and make all necessary connections and cross-connections required for complete installations. All inter-rack wiring between various equipment shall be shielded, twisted-pair cable.

3.02 PA SPEAKER INSTALLATION

A. In those locations where a PA Speaker enclosure is not imbedded, the Contractor shall install the appropriate type PA speaker enclosure. PA speaker enclosures are imbedded in the ceiling of the mezzanine areas, under the mezzanine structure, and in entrance passageways of the passenger station. No speaker enclosures are imbedded in service rooms and non-revenue passageways. Install surface mounted speaker enclosures or suspended ceiling mounted enclosures as appropriate.

B. Submit a proposed PA speaker layout for the passenger station to the Engineer for approval. This layout shall show each PA speaker, the matching transformer tap to be used and the total power per circuit.

C. Install the PA speaker, with matching transformer and associated speaker baffles, in the PA speaker enclosures.

D. Install the PA speaker, with matching transformer and associated speaker baffles, in the Pylon on the station platform.

E. Install the required cabling, hardware and material to connect the speakers (via matching transformers) to the appropriate Loudspeaker Distribution Panels. Furnish and install conduit between PA speaker.

3.03 COMMUNICATIONS EQUIPMENT ROOM INSTALLATION

A. Install the equipment on a 19-inch equipment rack in the Communications Equipment Room of the passenger station(s).

B. Distribute the 70.7-volt amplified audio to all speakers in the passenger station(s) using a Loudspeaker Distribution Panel for each zone.

C. All PA amplifiers shall be adjusted, internally or externally, via audio attenuators, to provide the full rated audio output for a 0 dBm input signal level.

D. Install the required cabling, connectors and plugs to provide 120-Vac, 60-Hz to the various PA equipment from the ac power receptacle strip on the PA equipment rack.

3.04 KIOSK INSTALLATION

A. Install a Kiosk Public Address Control Panel in the appropriate bay of the Kiosk cabinetry.

B. Install the voice pre-amp/processor in the appropriate bay of the Kiosk cabinetry.

C. Install a hand-held Gooseneck microphone on the appropriate bay of the Kiosk cabinetry. Furnish and install the required wiring harness between the Kiosk PA Control Panel and the Kiosk Cable Termination Rack in the Kiosk.

D. Install the wireless microphone receiver in the appropriate bay of the Kiosk cabinetry and mount the antenna on top of the Kiosk in a location approved by the Engineer. Furnish and

install the required wiring harness between the wireless microphone receiver and the Kiosk Cable Termination Rack in the Kiosk.

E. Install individually-shielded, twisted, pair cables between the Kiosk Cable Termination Rack and the appropriate PA equipment in the Communications Equipment Room. The Contractor shall use these cables to connect the Kiosk PA Control Panel and wireless microphone receiver to the appropriate PA System equipment within the Communications Equipment Room.

3.05 KIOSK-ATTENDANT/PASSENGER INTERPHONE SUBSYSTEM INSTALLATION

A. Install a complete operational Kiosk-Attendant/Passenger Interphone Subsystem in the Kiosk of the passenger station(s).

B. Surface-mount two Interphone Loudspeaker Enclosures to the exterior of the Kiosk structure at each passenger station. One Interphone Loudspeaker Enclosure shall be installed on the Kiosk door. The second Interphone Loudspeaker Enclosure shall be installed on the Kiosk structure associated with Bay Four of the Kiosk cabinetry. Exact locations shall be approved by the Engineer.

3.06 TERMINAL SUPERVISOR'S PUBLIC ADDRESS FACILITY INSTALLATION

A. Install a complete operational Dispatcher's Public Address Facility in the new end-of-line Passenger Station (if applicable).

B. Install a Public Address System Control Panel (same as the Kiosk PA System Control Panel), with microphone and a Loudspeaker Zone Selection Panel in a Tabletop Instrument Cabinet. The Contractor shall install the Tabletop Instrument Cabinet on top of the table/desk within the End-of-Line Terminal Supervisor's Room.

C. Install a junction box with terminals within the Terminal Supervisor's Room in a location approved by the Engineer.

D. Install a Terminal Supervisor's PA Zone Selection System for the Dispatcher's Facility.

E. Provide all components needed to implement the Terminal Supervisor's PA Zone Selection System, and install the following components as stated below:
   1. Install the Terminal Supervisor's PA Zone Selection Panel in the Terminal Supervisor's Room.
   2. Install the Terminal Supervisor's PA Zone Control Unit in the Station PA System Equipment Rack in the Communications Equipment Room.

F. Install individually shielded, twisted, three-pair audio cables, as needed, from the PA equipment in the Terminal Supervisor's Room to the Station PA Equipment Rack in the Communications Equipment Room, via the junction box with terminals. Install the necessary connections and cross-connections between the cables and the Kiosk PA Control Panel, Terminal Supervisor's PA Control Panel, Terminal Supervisor's PA Zone Selection Panel, Terminal Supervisor's PA Zone Control Unit; and the Station PA Control Unit. Connect the Terminal Supervisor's PA Control Panel to the Station PA Control Unit and the Terminal Supervisor's Zone Control Unit via the audio and control circuit connections assigned for Kiosk No. 3.

3.07 TERMINAL SUPERVISOR'S/TRAIN CONTROL ROOM/OPERATIONS ROOM INTERCOM

A. Install the Intercom Sub Station and the Surface-Mounted Enclosure in the Train Control Room and the Operations Room of the new Passenger Station in a location approved by the Engineer.

B. Install a junction box with terminals within the Train Control Room and the Operations Room in a location approved by the Engineer.

C. Install a two (2)-conductor cable from the Intercom Master to the Intercom Sub Stations in the Train Control Room, and the Operations Room, via the junction box installed at each location. The Contractor shall install the necessary connections and cross-connections to connect the Intercom Sub Station to the Intercom Master.

3.08 INTERFACE

A. Install the hardware and wiring required to connect the Automatic Public Address Announcement System equipment to the Passenger Station Public Address System equipment.

B. Install the required hardware and wiring to connect the alarm output of the Station PA Control Unit to the Main Distribution Frame.

C. Install the required cabling, hardware and material to connect the Carrier Transmission System to the Station PA Control Unit to provide for the Rail Operations Control Center announcements. Included in the installation is the wiring of -48 Vdc from the Carrier Transmission System Power Supply to the Station PA Control Unit to provide "M" lead signaling.

3.09 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 16707.

B. Supervise final wiring connections and system adjustments.

3.10 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

B. Adjust levels for proper sound levels in the services areas.

3.11 DEMONSTRATION

A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

F. Demonstrate system operation.

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

END OF SECTION

SECTION 16820
COMMUNICATIONS - PUBLIC ADDRESS SYSTEM

PART 1: GENERAL

1.01 SUMMARY

A. Public Address Systems are used to provide information to the public in passenger stations. Public Address Systems are also used to communicate with personnel in station service rooms. Separate public address systems shall be provided at each operational yard, facilities, and in shops.

B. Access to each Public Address System shall be provided to a local control station on an individual basis and to Jackson Graham Building and Carmen Turner Facility on an individual select, group select, or "all call" select condition control.

C. The Rail Operations Control Center (OCC) in the Jackson Graham Building and Carmen Turner Facility uses the PENTA PA Control Equipment to select and broadcast in the following ways:

1. System wide announcements to all Metro Rail Stations.
2. Announcements to selected Lines (i.e., Red Line, Green Line, Yellow line, Silver Line, or Blue/Orange lines).
3. Individual passenger stations.

D. Each passenger station in the WMATA Rail System shall be designed to have an independent Public Address (PA) system. The passenger station PA system provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the kiosk, the Rail Operations Control Center (ROCC) in the Jackson Graham Building and Carmen Turner Facility, and end-of-line station's dispatcher's room.

E. A line Priority mixer shall be used to control the level of these individual inputs.

F. The PA system shall provide noise compensated circuits to the platform and mezzanine areas, where train noise must be overcome by automatically adjusting the PA volume.

G. Non-noise compensated circuits shall be provided for service rooms and non-revenue passageways, these areas normally do not require noise compensation.

H. The PA system design shall be such that announcements that are made over the PA system will be managed in accordance with the following access priority:
1. Fire Emergency Evacuation Announcements.
2. Wireless Microphone
3. Rail Operations Control Center (ROCC) in the Jackson Graham Building and Carmen Turner Facility.
4. Kiosk Microphone.
5. End-of-line Dispatcher

When an announcement of a higher priority is initiated, the lower priority announcement is removed from the amplifier's input until the high priority announcement is completed.

I. The operation of the passenger station PA system from the kiosk is accomplished by simultaneously depressing the push-to-talk pushbutton on the kiosk PA Control Panel, then speaking into the Goose Neck microphone. The diversity wireless receiver is connected to the PA system so as to by-pass and takes the place of the normal kiosk microphone when the wireless microphone is keyed. This feature is used to allow the kiosk attendant freedom of movement beyond the kiosk for various reasons including crowd control.

J. When a selection is made by a Passenger Operations Supervisor in the Rail OCC, the audio path of the console is connected to the PA system channel of the selected passenger station's Carrier Transmission System terminal for transmission to the selected passenger station(s). At the passenger station, the audio path from the assigned PA system channel of the Carrier Transmission System is connected to the station PA Control Unit.

K. The Dispatcher's PA Control Panel shall function in an identical manner as the kiosk Public Address Control Panel. (Loudspeaker zone selection is not available at the kiosk).

L. The PA system's design shall have redundant power amplifiers. The power amplifiers shall be connected to the Amplifier Supervisory Control Unit. One power amplifier shall be connected to the "MAIN CHANNEL" of the Amplifier Supervisory Control Unit, and the second power amplifier shall be connected to the "auxiliary channel" of the Amplifier Supervisory Control Unit. Each Amplifier Supervisory Control Unit shall monitor the associated power amplifiers and, upon sensing a malfunction of the "main channel" power amplifier, shall automatically transfer the audio path to the "auxiliary channel" power amplifier.

M. The passenger station PA speakers shall be designed to be wired in either noise-compensated or non-noise compensated circuits. Noise-compensated circuits shall be used in areas where train noise must be overcome by automatically adjusting the PA volume. The station mezzanine area and platform areas are of noise compensated circuits, which use Automatic Level Control. For areas where noise compensation is required, circuits shall be wired to the Loudspeaker Distribution Panel designated for noise- compensated circuits. Non-noise compensated circuits shall be used in all other areas. In areas where noise-compensated circuits are not required, circuits shall be wired to the Loudspeaker Distribution Panel designated for non-noise compensated circuits. Passenger station service rooms and non-revenue passageways are examples of areas that require non-noise compensated speaker circuits.

N. Each kiosk in the WMATA Rail System shall be designed to have an Attendant/Passenger Interphone System. The Attendant/Passenger Interphone System

shall provide for communication between passengers and the kiosk attendant at the kiosk. The Attendant/Passenger Interphone System shall serve both the “PAID” and the “UNPAID” side of each kiosk.

O. A sufficient quantity of speakers shall be placed in passenger stations to give even volume distribution without objectionable loudness from any one speaker location.

P. The PA amplifiers shall have a constant voltage output of 70.7 volts. Each loudspeaker shall be equipped with an audio transformer to match the 70.7-volt line with the loudspeaker. The transformers shall have various taps to allow for adjustment of the sound level in a particular area. Each transformer shall have a minimum of four taps. The power rating for each of the taps shall be determined during installation.

Q. Design of public address systems in stations shall be coordinated with architectural design.

R. The Contractor shall have full responsibility to survey station, communication room, and services rooms and coordinate all work with WMATA’s engineers.

1.02 SECTION INCLUDES

A. Loudspeakers in the passenger station, passenger walkway, and services areas.

B. Control hardware in the Kiosks and End-Of-Line dispatcher office.

C. Control and amplification equipment in the Communication Equipment Room.

D. Wireless Microphone System in the Kiosk.

E. End-Of-Line dispatcher office.

F. Fire Alarm System

1.03 UNIT PRICES

A. Unit Prices include all equipment racks, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, all the connections and cross- connections required for a complete operational installation of the Public Address System and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.04 RELATED SECTIONS

A. Section 16705 - Communications Standard Specifications - Equipment & Materials.

B. Section 16707 - Communications Systems Quality Assurance & Testing

C. Section 16710 -Communications Grounding.

D. Section 16715 - Communications Electrical Power Distribution.

E. Section 16733 - Communications - Kiosk Systems

F. Section 16820-2 – Communications Public Address System Facilities

G. Section 16732 Communications Fire Alarm System

1.05 REFERENCES

A. National Electric Code (NEC).

B. National Fire Alarm Code (NFPA 72)

C. UL Standard (*for the intend use*) 1480, Speakers for Fire Protective Signaling Systems.

1.06 SYSTEM DESCRIPTION

A. Description: Provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the Fire Alarm Equipment Panel, Kiosk Manager, End-of-line Dispatcher, the Rail OCC in the Jackson Graham Building and Carmen Turner Facility.

B. The dispatcher PA system, in end-of-line stations, shall provide access to the passenger station PA system to make announcements to the station platform and mezzanine at any time that the PA system is not already in use.

C. Capacity:

1. The Contractor shall design the placement of Type 1 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
2. The Contractor shall design the placement of Type 2 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
3. The Contractor shall design the placement of Type 3 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
4. The Contractor shall furnish and install a kiosk PA Control Panel(s) constructed in accordance with contract specifications and drawings.
5. The Contractor shall furnish and install a station PA Control Unit(s) constructed in accordance with contract specifications and drawings.
6. The contractor shall furnish, and install gooseneck public address microphone and cables accordance with contract specifications and drawings.
7. The contractor shall furnish, and install an audio voice processor in accordance with contract specifications and drawings.
8. The contractor shall furnish, and install an audio priority mixer in accordance with contract specifications and drawings.
9. The Contractor shall furnish, and install a DSP engine audio compressor/limiter in accordance with contract specifications and drawings.
10. The Contractor shall furnish, and install an audio distribution amplifier in accordance with contract specifications and drawings.

11. The Contractor shall furnish, and install an ambient noise sensor in accordance with contract specifications and drawings.
12. The Contractor shall furnish, and install a digital equalizer in accordance with contract specifications and drawings.
13. The Contractor shall furnish, and install a 60-watt power amplifier in accordance with contract specifications and drawings.
14. The Contractor shall furnish, and install a 120-Watt Power Amplifier in accordance with contract specifications and drawings.
15. The Contractor shall furnish, and install wireless microphone transmitter equipment, wireless receiver equipment, antennas, and cables in accordance with contract specifications and drawings.
16. The Contractor shall furnish, and install a 24-Vdc power supply in accordance with contract specifications and drawings.
17. The Contractor shall design, furnish, and install a custom loudspeaker distribution panel in accordance with contract specifications and drawings.
18. The Contractor shall design, furnish, and install a custom Audio and control distribution panel in accordance with contract specifications and drawings.
19. The Contractor shall design, furnish, and install a custom Loudspeaker Zone Attenuator Assembly in accordance with contract specifications and drawings.
20. The Contractor shall furnish, and install a PA Patch Panel Assembly in accordance with contract specifications and drawings.
21. The Contractor shall furnish, and install end-of-line dispatcher PA equipment.
22. The Contractor shall design, furnish, and install Loudspeaker accordance with contract specifications and drawings.
23. The contractor will take full responsibility for total design of the public address system with WMATA's engineer's approval.
24. The Contractor shall design, furnish, and install Wireless PA equipment accordance with contract specifications and drawings.

1.07 SYSTEM PERFORMANCE REQUIREMENTS

A. The contractor shall be responsible for the overall performance of the PA system. The following overall system performance requirements are designed to ensure that the PA system, delivered under these specifications, meets the performance requirements of the Washington Metropolitan Area Transit Authority.

1. PA Overall Frequency Response: ±5db or better 200-Hz to 8,000-Hz
2. PA Sound Pressure Levels: 85 dB minimum measured 3 meter from front of each canopy, pylon, ceiling, and passageway speaker.
3. PA Overall Harmonic Distortion: Less than 1% 200-Hz to 8,000-Hz.

1.08 SUBMITTALS

A. Submit under provisions of Section 16706.

1. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.

2. Product Data: Provide showing electrical characteristics and connection requirements for each component.
3. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
4. Final As-Built drawings.
5. Operation and Maintenance manuals, preventative maintenance recommendations, and product data sheets.

1.09 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

C. Installer: Service facilities within 50 miles of Project.

1.10 MAINTENANCE SERVICE

A. Furnish service and maintenance of Public Address System until Final Completion.

PART 2: PRODUCTS

2.01 SPEAKERS ASSEMBLY PYLON, PARAPET, and CEILING

A. Manufacturers:

1. Atlas- Sound loud speaker assembly Pylon Square or Round Horn Speaker (or approved equal)
2. Atlas- Sound loud speaker assembly Pylon Vandal Resistant Square Speaker Grill (or approved equal)
3. Atlas- Sound loud speaker assembly Pylon Weather Proof Square Surface Speakers Enclosure (or approved equal)
   - Weight: 10-ounces.
   - Material: Ceramic.
   - Flux Density: 9K gauss.
   - DC Resistance: 7.4 ohms.
   - Diameter: One inch.
   - Power Handling: 15-Watts.
   - Transformer: 70-volt multi-tap at 4, 2, 1, and .5watts.
   - Frequency Response: 80-Hz to 8-KHz.
   - Sensitivity: 95db.
   - Depth: 3-1/4 inches.

- Transformer Mounting: Min 2 inches – Max 2-13/16 inches.
- Mounting Hole Circle: 7-5/8 inches.
- Baffle Opening: Seven inches.
- Cone: 8-inch full range moisture proof.
- Grill: Custom finish color to match current WMATA pylon color.

4. Quam-Nichols loudspeaker assembly replacement (or approved equal)
5. Quam-Nichols loudspeaker assembly parapet kit includes: speaker, TBLU transform, grill, and enclosure (or approved equal)

2.02 SPEAKERS ASSEMBLY STAFF SERVICE AREAS

A. Manufacturers:

1. Atlas- Sound loud speaker Loudspeaker assembly (VT 157U-C-N) Description: Speakers for use in service. (or approved equal)

- Transformer: 70.7-Volts.
- Power Taps: 1 and 2 Watts
- Frequency Response: 600-Hz to 5500-Hz (± 5db).
- Sensitivity: 96.9dB (1-watt at 1-meter).
- Dimensions: 4-1/2 inches, square.
- Color: Neutral Gray.
- Construction: Die-cast zinc, water/moisture sealed.

2.03 KIOSK PA CONTROL PANEL

A. Manufacturers:

1. Custom Item.

B. Description: Station Manager's Public Address System Control Panel.

2.04 STATION PA CONTROL UNIT

A. Manufacturers:

1. Custom Item.

B. Description: Control and interface unit for the PA system

2.05 DUAL ZONE PRIORITY MIXER

A. Manufacturers:

1. Symetrix, Inc. Jupiter 8 (or approved equal).

B. Description: Mixer with eight (8) levels of priority.

C. Ratings:

1. Microphone inputs: Two, low impedance, balanced.
2. Microphone Common Mode Rejection: >85dB @ 1KHz, 1 Volt RMS.
3. Line Inputs: eight, stereo.
4. Line Input Impedance: > 10K ohms, balanced.
5. Line Common Mode Rejection: >40dB @ 1KHz, 1 Volt RMS.
6. Line Input Level: +24dBu balanced, +18dBu unbalanced maximum.
7. Frequency Response: ±1 dB, 20-Hz to 20-KHz any input to any output.
8. Mounting: 19-inch rack.
9. Power Input: 120-Vac.

2.06 COMPRESSOR/LIMITER

A. Manufacturers:

1. Symetrix, Inc. Model 322 (or approved equal).

B. Description: DSP Engine Audio Leveler (Compressor/Limiter) Mounting: 19-inch rack

2.07 AUDIO DISTRIBUTION AMPLIFIER

A. Manufacturers:

1. Symetrix, Inc. Model 581E (or approved equal).

B. Description: 4 input/ 16 output audio distribution amplifier.

1. Maximum Output Level: +26dBu Balanced (20k ohm load), +22dBm (600 ohm load).
2. Input Impedance: 20k ohms balanced, 10k ohms unbalanced.
3. Output Impedance: 200 ohms balanced, 100 ohms unbalanced.
4. Frequency Response: ± 0.5dBm, 20-Hz to 20-KHz.
5. Input Gain Range: ± 15dB.
6. Output Gain Range: 0 to –20dB.

2.08 AMBIENT NOISE SENSOR MICROPHONE (ANSM)

A. Manufacturers:

1. Crown Model No PZM-11 (or approved equal)

2.09 AMBIENT NOISE COMPENSATION PROCESSOR (ANCP)

A. Manufacturers:

1. Symetrix Model No 371 (or approved equal)

B. Description: Ambient sensing automatic level controlling device to regulate the operating level of a sound system in proportion to changing noise levels in the sound system's operating area.

C. Ratings:

1. Inputs: Two sensing mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one paging mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one line (0dBu nominal) CMRR=< 40dB at 1-KHz, one music (-10dBu nominal) CMRR =< 40dB at 1-KHz
2. Maximum Input Level: -30dBu (mic inputs), +18 (line inputs).
3. Input Impedance: Mic: electronically balanced bridging 200 ohms, nominal (not phantom powered). Line: electronically balanced bridging 20 kilo ohms nominal.
4. Phantom Power (on all mic inputs): 15-Vdc.
5. Output: Balanced, transformer.
6. Output Impedance: 100 ohms.
7. Maximum Control Range: 40dB.
8. Ambient noise to Gain Ratio: Variable, 2:1 to 1:2.
9. Averaging Time: 1.2 sec. to 5 min.
10. Page-Over Music (ducking): Variable, 0 to 14 dB
11. Frequency Response: 20-Hz to 20-KHZ (+ 1 dB,-0 dB).
12. Power Input: 120-Vac 60-Hz.
13. Mounting: 19-inch rack.

2.10 DIGITAL AUDIO EQUALIZER

A. Manufacturers:

1. Shure Model No. DFR-11EQ (or approved equal).

B. Description: Digital 1/3 Octave graphic equalizer, automatic and manual acoustic feedback suppression for 10 frequencies, digital delay compressor/limiter.

C. Ratings:

1. Remote Programming: RS232C serial port, USB, Category 6 .
2. Frequency Response: 20-Hz to 20-KHz ± 1.0dB reference 1 KHz.
3. Dynamic Range: 104db minimum, A-weighted, 20-Hz to 20-KHz.
4. Sampling Rate: 48-KHz.
5. Digital-to-Analog, Analog-to-digital Conversion: 20-bit resolution.
6. Voltage Gain:
7. LED Signal Indicators: Clip: 6dB down from input clipping.
8. Feedback Filters:
9. Graphic Equalizer:
10. Parametric Equalizer:
11. Delay: Up to 1300ms.
12. Limiter:
13. Mounting: 19-inch rack.
14. Power Input: 120-Vac 60-Hz.

2.11 60-WATTS POWER AMPLIFIER

A. Manufacturers:

1. Crown Model No. 180 A with rack mount kit (or approved equal).

B. Description: Audio power amplifier.

C. Ratings:

1. Output Power: 80-watts RMS.
2. Frequency Response: 20-20,000 Hz, +1dB/-3 dB
3. Inputs: One input port, one direct.
4. Input Sensitivity/Impedance:
5. Output:
    a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
    b. Main (Direct): 4 ohms, unbalanced.
6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
7. Power Input: 120-Vac 60-Hz, 100-watts.
8. Mounting: 19-inch rack.
9. Input Module: balanced line input, 10k ohms.

2.12 120-WATTS POWER AMPLIFIER

A. Manufacturers:

1. Crown Model No. 1160A rack mounting kit (or approved equal)

B. Description: Audio power amplifier.

C. Ratings:

1. Output Power: 120-watts RMS
2. Frequency Response: 20-20,000 Hz, +1dB/-3dB.
3. Inputs: One input port, one direct.
4. Input Sensitivity/Impedance:
    a. Input Port: 100 mV or 1000 mV (switchable)/10 K ohms.
    b. Direct Input: 100 mV or 1000 mV (switchable)/10 K ohms.
5. Outputs:
    a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
    b. Main (Direct): 4 ohms, unbalanced.
6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
7. Power Input: 120-Vac 60-Hz, 180-watts.
8. Mounting: 19-inch rack.
9. Input Module: line input, 10k ohms.

2.13 OCC AUDIO INPUT STATION CONTROLLERS

A. Manufacturers:

1. Barix Corporation (Annuncicom100)
2. Penta Corporation (Firmware)

B. Description: Self-contained streaming VoIP with serial interface and digital I/O

C. Features:

1. Operates on 9 to 30 VDC / 12 to 24 VDC
2. 1 or 2 unit rack mounts kit (1RU)
3. 300 to 115.2K Baud RS-232 port
4. Web-based configuration
5. 10/100 Mbit Ethernet, TCP/IP UDP, SNMP
6. G7.11 and PCM Audio Compression
7. Mic In, Line In, Line Out, Speaker Out
8. Support Penta VoIP control protocol

D. Provide a Barix Rack Mount and install on the equipment racks in the Communication Equipment Room at each passenger station.

2.14 WIRELESS MICROPHONE TRANSMITTER AND RECEIVER

A. Manufacturers:

1. Shure Model No. ULXP4: microphone receiver system (or approved equal).
2. Shure Model No. ULX2/58: microphone (or approved equal).
3. Shure Model No. UA505: remote antenna mounting brackets and BNC connectors.
4. Shure Model No. UA820: ½ wave dipole antenna UXL receiver.
5. Shure Model No. UA830: UHF in-line amplifier.
6. Shure Model No.A13HDB: mounting flange, heavy duty in amplifier.
7. Shure Model No. UA2212: passive antenna combiner/splitter.

B. Description: The wireless microphone receiver system equipment shall be mounted in the kiosk. The wireless antenna shall be placed on top on the kiosk. The wireless system shall cover 95% on the station.

C. Ratings:

1. RF Carrier Frequency Range: 554-590 MHz
2. Working Range 700 ft. minimum under typical conditions.
3. Audio Frequency response: 45 to 15,000 Hz ±2dB.
4. Gain Adjustment Range: -6 to 26 dB.

5. Receiver Audio Output Level (Maximum):
   a. Unbalanced: + 5dBu typical. b. Balanced: + 14dBu typical.
6. RF Sensitivity: -108dBm at 12dB SINAD.
7. Image Rejection 90dB typical.
8. Spurious Rejection 70dB typical.
9. Power Requirements:
10. Microphone 9V alkaline battery.

2.14 24-VDC POWER SUPPLY

A. Manufacturers:

1. ADC

2.15 LOUDSPEAKER DISTRIBUTION PANEL

A. Manufacturers:

1. Custom assembly by contractor.

2.16 LOUDSPEAKER ZONE ATTENUATOR ASSEMBLY

A. Manufacturers:

1. Atlas-Soundolier Model No. AT-10: Loudspeakers Attenuator 70 volts(or approved equal).

2.17 PA PATCH PANEL ASSEMBLY

A. Manufacturers:

1. ADC Model No.PPA3-14MKIVNS (or approved equal). Patch panel assembly for the audio power amplifiers and audio signal.

B. Ratings:

1. Number of Jacks: Two rows of 24
2. Insertion Loss: Less than 0.1dB
3. Jack Circuits Configuration: Top-to-bottom row jack circuits.
4. Punch Block: Rear mounted proprietary 66-terminal punch block for solid and stranded wire (Flexi-block)
5. Chassis and Brackets: Aluminum
6. Mounting: 19-inch rack.
7. Compatibility: Standard ¼ inch 3-conductor phone shielded audio patch cords. Provide printed designation labeling for each jack.

2.18 PATCH PANEL PUNCH TOOL

A. Manufacturers:

1. ADC Model No. QB-4 (or approved equal). Compatible with wiring punch blocks included with patch panel.

2.19 MICROPHONE WITH 18" GOOSENECK

A. Manufacturers:

1. Shure SM57 (microphone) with Shure A12 (mounting flange), with Shure G18-CN (18" Gooseneck), with Shure A2WS (windscreen) (or approved equal).

2.20 AC POWER LINE CONDITIONER-20 AMP

A. Manufacturers:

1. New Frontier Electronics Surge-X SX2120 (or approved equal). B. Description: Electrical power line surge suppressor and line conditioner.

B. Ratings:

1. Mounting: 19-inch rack.
2. Current: 20 amps at 120-Vac.
3. Rear Outlets: 12 switched, two un-switched.
4. Front Panel Indications: Electrical service and surge fault.
5. Front Panel Switches: One for switched outlets.

C. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.

2.21 AC POWER LINE CONDITIONER, 15-AMP

A. Manufacturers:

1. New Frontier Electronics Surge-X SX115R (or approved equal). B. Description: Electrical power line surge suppressor and line conditioner.

B. Ratings:

1. Mounting: 19-inch rack.
2. Current: 15-amps at 120-Vac.
3. Rear Outlets: Six switched two un-switched.
4. Front Panel Indications: Electrical service and surge fault.
5. Front Panel Switches: One for switched outlets.

C. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.

2.22 SHIELDED TWISTED-PAIR CABLE (16-AWG)

A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 60 watts. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

B. Ratings:

1. Conductors: 16-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

2.23 SHIELDED TWISTED-PAIR CABLE (14-AWG)

A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 120 watts. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

B. Ratings:

1. Conductors: 14-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

2.24 SHIELDED MULTI-TWISTED-PAIR CABLE (20-AWG)

A. Description: Audio cable for all audio wiring and ambient noise and paging microphones. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

B. Ratings

1. Conductors: 20-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

2.25 SHIELDED MULTI-TWISTED-PAIR CONTROL SIGNALING/AUDIO CABLE

A. Description: control signaling multi-pair cable type, for all control and DC voltage wiring.

B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.

C. Ratings:

1. Conductors: 18-AWG stranded twisted pairs ASTM tinned copper with overall 100% foil shield.

PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Install a complete and operational passenger station Public Address System, as described herein, in the passenger station(s). This includes installations in the Kiosk(s), Communications Equipment Room(s) and Dispatcher's Facility.

B. Install all terminals, hardware, wiring and cabling, conduits, and fittings. The Contractor shall install the required connectors, attenuators, baluns, audio isolation transformers, and inter-rack wiring between the various equipment, and make all necessary connections and cross-connections required for complete installations. All inter-rack wiring between various equipment shall be shielded, twisted-pair cable.

C. The Contractor shall have full responsibility to survey station, communication room, services rooms before any work is completed.

3.02 PA SPEAKER INSTALLATION

A. In those locations where a PA Speaker enclosure is not imbedded, the Contractor shall install the appropriate type PA speaker enclosure. PA speaker enclosures are imbedded in the ceiling of the mezzanine areas, under the mezzanine structure, and in entrance passageways of the passenger station. No speaker enclosures are imbedded in service rooms and non-revenue passageways. Install surface mounted speaker enclosures or suspended ceiling mounted enclosures as appropriate.

B. Submit a proposed PA speaker layout for the passenger station to the Communication Engineer for approval. This layout shall show each PA speaker, the matching transformer tap to be used and the total power per circuit.

C. Install the PA speaker, with matching transformer and associated speaker baffles, in the PA speaker enclosures.

D. Install the PA speaker, with matching transformer and associated speaker baffles, in the Pylon on the station platform.

E. Install the required cabling, hardware and material to connect the speakers (via matching transformers) to the appropriate Loudspeaker Distribution Panels. Furnish and install conduit between PA speakers.

3.03 COMMUNICATIONS EQUIPMENT ROOM INSTALLATION

A. Install the equipment on a 19-inch equipment rack in the Communications Equipment Room of the passenger station(s).

B. Distribute the 70.7-volt amplified audio to all speakers in the passenger station(s) using a Loudspeaker Distribution Panel for each zone.

C. All PA amplifiers shall be adjusted, internally or externally, via audio attenuators, to provide the full rated audio output for a 0 dBm input signal level.

D. Install the required cabling, connectors and plugs to provide 120-Vac, 60-Hz to the various PA equipment from the ac power receptacle strip on the PA equipment rack.

3.04 KIOSK INSTALLATION

A. Install a Kiosk Public Address Control Panel in the designated bay of the Kiosk cabinetry.

B. Install the voice pre-amp/processor in the appropriate bay of the Kiosk cabinetry.

C. Install a hand-held Gooseneck microphone on the appropriate bay of the Kiosk cabinetry. Furnish and install the required wiring harness between the Kiosk PA Control Panel and the Kiosk Cable Termination Rack in the Kiosk.

D. Install the wireless microphone receiver in the appropriate bay of the Kiosk cabinetry and mount the antenna on top of the Kiosk in a location approved by the Engineer. Furnish and install the required wiring harness between the wireless microphone receiver and the Kiosk Cable Termination Rack in the Kiosk.

E. Install individually-shielded, twisted, pair cables between the Kiosk Cable Termination Rack and the appropriate PA equipment in the Communications Equipment Room. The Contractor shall use these cables to connect the Kiosk PA Control Panel and wireless microphone receiver to the appropriate PA system equipment within the Communications Equipment Room.

3.05 TERMINAL SUPERVISOR'S PUBLIC ADDRESS FACILITY INSTALLATION (End of line)

A. Install a complete operational Dispatcher's Public Address Facility in the new end-of-line Passenger Station (if applicable).

B. Install a Public Address System Control Panel (same as the Kiosk PA System Control Panel), with microphone and a Loudspeaker Zone Selection Panel in a Tabletop Instrument Cabinet. The Contractor shall install the Tabletop Instrument Cabinet on top of the table/desk within the End-of-Line Terminal Supervisor's Room.

C. Install a junction box with terminals within the Terminal Supervisor's Room in a location approved by the Engineer.

D. Install a Terminal Supervisor's PA Zone Selection System for the Dispatcher's Facility.

E. Provide all components needed to implement the Terminal Supervisor's PA Zone Selection System, and install the following components as stated below:

1. Install the Terminal Supervisor's PA Zone Selection Panel in the Terminal Supervisor's Room.

2. Install the Terminal Supervisor's PA Zone Control Unit in the Station PA System Equipment Rack in the Communications Equipment Room.

F. Install individually shielded, twisted, three-pair audio cables, as needed, from the PA equipment in the Terminal Supervisor's Room to the Station PA Equipment Rack in the Communications Equipment Room, via the junction box with terminals. Install the

necessary connections and cross-connections between the cables and the Kiosk PA Control Panel, Terminal Supervisor's PA Control Panel, Terminal Supervisor's PA Zone Selection Panel, Terminal Supervisor's PA Zone Control Unit; and the Station PA Control Unit. Connect the Terminal Supervisor's PA Control Panel to the Station PA Control Unit and the Terminal Supervisor's Zone Control Unit via the audio and control circuit connections assigned for Kiosk No. 3.

3.06 INTERFACE

A. Install the hardware and wiring required to connect the Fire Alarm System "Emergency Evacuation Announcements" to the Passenger Station Public Address System equipment.

B. Install the required hardware and wiring to connect the alarm output of the Station PA Control Unit to the Priority Mixer.

C. Install the required cabling, hardware and material to connect WMATA'S WAN/LAN system.

3.07 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 16707.

3.09 DEMONSTRATION

A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

F. Demonstrate system operation.

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

END OF SECTION

SECTION 28 23 11

COMMUNICATIONS – CLOSED-CIRCUIT TELEVISION SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes: a complete and operational Closed-Circuit Television (CCTV) System for monitoring WMATA's rail system, parking garages, bus divisions and support facilities using the following features, devices, and equipment:

1. Network-Based IP Cameras
2. Networking Devices
3. Mounting Hardware

B. Related Requirements:

1. Section 27 00 30 Communications Standard Specifications-Engineering Services
2. Section 27 00 40 Communications Standard Specifications-Installation
3. Section 27 06 05 Communications Standard Specifications-Equipment & Material
4. Section 27 06 05.02 Communications System Submittals & Services
5. Section 27 00 70 Communications System Quality Assurance & Testing
6. Section 27 05 26 Grounding and Bonding for Communications Grounding Systems
7. Section 27 05 14 Communications Electrical Power Distribution
8. Section 27 02 10 Communications – Kiosk Systems
9. Section 34 21 04 Wire, Cable and Busways
10. Section 34 21 05 Raceways, Boxes and Cabinets

1.03 REFERENCES

A. Reference Standards:

1. National Electrical Code (NEC)
2. National Fire Protection Administration (NFPA) 130
3. Electronics Industries Alliance (EIA) Standard RS 170
4. Federal Standard 595B, Colors Used in Government Procurement
5. WMATA's most current Design and Wiring Standards

1.04 SUBMITTALS

A. Submit the following for approval in accordance with Section 27 06 05.02 and with the additional requirements as specified for each:

1. Design
   a. Submit the optimum design layout of the cameras and camera specifications prior to installing any equipment. The Contractor will use the layout to determine the adequacy of the design and, in conjunction with a field survey, determine the exact location of each CCTV camera.
   b. Contractor shall consider the distance of target and purpose of camera when selecting and locating cameras.
   c. Contractor shall consider the movement and crowding of people in stations and equipment in rail yards and bus garages; space is never fully open as it appears on paper.
   d. Contractor shall consider signage in facilities when placing cameras.
   e. Method of camera installation shall limit exposed conduit, conduit runs shall be aligned with structure vertical and horizontal lines.
   f. Communication enclosure size shall be minimized and units shall be installed away from or concealed from the public when possible. All enclosure assemblies shall be stainless steel, UL508 certified and contain cable management for both copper and fiber, ample terminals shall be provided to manage incoming and equipment power distribution.
   g. At least 3 open ports shall be designed into switch port allocation.
   h. External cameras that connect via CAT 6 cabling shall be provided with external surge suppression.
   i. Enlarged plans shall be provided when the scaled floor plan cannot represent the location of equipment properly.
2. Design Drawings:
   a. Proposed changes and revised equipment layouts
   b. System riser diagrams, communication devices only, identifying cable types and all termination points (patch panels, LIU).
   c. System power distribution diagram to include power panel, breaker and equipment enclosure termination.
   d. CCTV equipment mounting details, accurate to the cameras and mounts to be used.
   e. Completed camera and equipment schedules
   f. Bill of materials shall reflect all major design components: cameras, camera mounts, monitors, switches, media converters, extenders, enclosures, back plains, cables specific to equipment, and accurate quantities.
3. Product Data:
   a. Provide product data sheets for each item of equipment and resubmittal for equipment which changes as a result of required modification.
   b. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   c. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
4. Manufacturer's Installation Instructions
   a. Indicate application conditions and limitations of use, stipulated by product testing agency.
   b. Include instructions for storage, handling, protection, examination, preparation, installation and start-up of Product.
5. Certification
   a. Certificates from manufacturers verifying that equipment conforms to the specified requirements.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of any and all custom fabricated components.
4. Include diagrams for power, signal, control wiring and system risers.
5. All camera, enclosure, switches and intermediate devices shall be named and labeled using WMATA naming guidelines.

1.05 CLOSEOUT SUBMITTALS

A. Operation and maintenance (O & M) manuals:

1. Complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of personnel.
2. Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in system.
3. Make data contained specific for and exclusive to the systems and equipment for the work of this Contract.
4. Field test data and reports.

B. As-Built Documents:

1. Prior to Substantial Completion, develop As-Built documents as follows:
   a. As-Built Drawings of the CCTV system installation to include, but not be limited to camera layouts, communication and power cable pathways and wiring, equipment details and equipment schedules.
   b. Final Bill of Materials shall reflect all major design components: cameras, monitors, switches, media converters, extenders, enclosure, back plains, cables specific to equipment, and accurate quantities. Part numbers and manufacturers shall be identified for: CAT6, fiber optic cable, power cable and any other custom built cables used to build the CCTV system.
      1) Readable when painted 11 x 17 format.
   c. Approved copies of each submittal

C. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.06 EXTRA MATERIALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide spare parts and/or equipment for no less than 10% of new items that are added to WMATA's inventory under this task.

1.07 QUALITY ASSURANCE

A. Qualifications:

1. Equipment manufacturer:
   a. Select a manufacturer who is engaged in production of similar CCTV products and accessories.
2. Equipment supplier:
   a. An authorized distributor of specified manufacturer with minimum three years documented experience.
3. Equipment installer:
   a. A manufacturer authorized installer of specified products with service facilities within 100 miles of WMATA.
4. Coordination
   a. Installer shall coordinate CCTV installation with all other concurrently running work at the location specified under this task.
5. For Code, Regulations, Reference Standards and Specifications, refer to Articles 1.02 and 1.03 above.
6. The Contractor shall develop test procedures and obtain System Design Engineer's approval prior to final acceptance testing.
7. The Contractor shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including but not limited to proper component operation and input/output signal operations.
   a. The Contractor's Quality Assurance Engineer shall witness all progressive testing.
   b. All discrepancies found during testing shall be corrected and test reports submitted prior to scheduling end-to-end testing.
   c. The Contractor shall notify the Engineer prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.
8. End-to-End Test:
   a. The Contractor shall demonstrate the proper functioning of the completed CCTV system.
   b. Each camera shall be viewable from all points of monitoring as specified in the design drawings.
   c. The Contractor shall submit certified test reports within 10 working days after completion of field tests.

B. Manufacturer Qualifications: Select a manufacturer who is engaged in production of similar CCTV products and accessories.

C. Equipment supplier: An authorized distributor of specified manufacturer with minimum three years documented experience.

D. Equipment installer:

1. A manufacturer authorized installer of specified products with service facilities within 100 miles of WMATA.

2. Technicians shall be trained on equipment being installed and shall be able to configure devices taking in lighting conditions during daily use.
3. Installer shall coordinate CCTV installation with all other concurrently running work at the location specified under this task.
4. Installer shall develop test procedures and obtain Engineer approval prior to final acceptance testing.
5. Installer shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including but not limited to proper component operation and input/output signal operations and preform corrective action as needed.

1.08 QUALITY CONTROL

A. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.

1. All CCTV communication enclosures shall be pre certified UL508A. All enclosures shall have an UL508A certification sticker as proof of certification.
2. All enclosures and back planes shall be stainless steel, NEMA 4X with: internal file pocket, locking padlock hasp, grounding kit, and stainless-steel mounting tabs.
3. Enclosure size shall be minimized but still leave space for air circulation, bend radius of both fiber and copper cables and serviceability.
4. All enclosures shall incorporate compact cable management for both copper and fiber cables. Units shall be easily installed on standard 35mm din rails. Panels shall be constructed from lightweight aluminum. Housing should with stand temperatures from -20°C to 70°C and resistant to shock and vibrations.
5. All enclosures shall use din-rail feed through and ground terminals to manage power and ground wires from all external sources to all internal devices.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Deliver all components, devices, equipment, and products in their original sealed containers and packaging.

B. Storage and Handling Requirements:

1. Protect, store, and handle as per manufacturer’s written instructions and as per WMATA’s project requirements.

PART 2 - PRODUCTS

2.01 COMPONENTS - Provided Products/Components Represent Minimal Requirements can contractor may provide equivalent equipment with explicit approval from WMATA ESS COMM Engineer.

A. PTZ DOME NETWORK CAMERA: Make and Model: Axis Q6055-E or approved equal

1. Sensors & optics
   a. The camera shall be equipped with an IR-sensitive progressive scan sensor.
   b. The camera shall contain a removable IR-cut filter providing Day/Night functionality.
   c. The camera shall meet or exceed the following illumination specifications:
      1) 0.3 lux at 30 IRE F1.6 (color)
      2) 0.03 lux at 30 IRE F1.6 (B/W)
      3) 0.5 lux at 50 IRE F1.6 (color)
      4) 0.04 lux at 50 IRE F1.6 (B/W)
   d. The camera shall provide 32x optical zoom.
   e. The camera shall provide 12x digital zoom.
   f. The camera shall provide adjustable zoom speed.

2. Image Control
   a. The unit shall incorporate Automatic and Manual White Balance.
   b. The camera shall incorporate Wide Dynamic Range - providing up to120dB dynamic range.
   c. The camera shall incorporate an electronic shutter operating in the range of:
      1) 1/33000 s to 1/3 s (50 Hz)
      2) 1/33000 s to 1/4 s (60 Hz)
   d. The camera shall incorporate highlight compensation functionality.
   e. The camera shall incorporate a function for optimization of low light behavior.
   f. The camera shall provide backlight compensation.

3. Video

   a. All cameras shall be compatible with the Verint video management system and the VMS ability to retrieve video from camera video storage.
   b. The camera shall provide simultaneous Motion JPEG and H.264 video streams.
   c. The camera shall be designed to provide at least two video streams in HDTV 1080p (1920x1080) at up to 30 frames per second (60Hz mode) or 25 frames per second (50Hz mode) using H.264 or Motion JPEG.
   d. The camera shall be designed to provide at least two video streams in HDTV 720p (1280x720) at up to 60 frames per second (60Hz mode) or 50 frames per second (50Hz mode) using H.264 or Motion JPEG.
   e. The camera shall support H.264 Baseline, Main and High Profile.
   f. The H.264 implementation shall include both unicast and multicast functionality and support Maximum Bit Rate (MBR) as well as Variable Bit Rate (VBR).
   g. The camera shall support H.264 with automatic scene adaptive bitrate control.
   h. The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.

4. Pan Tilt functionality

   a. The camera shall provide more than 255 manually set preset positions.
   b. The camera shall provide e-flip functionality, which will automatically rotate the image 180° electronically when following a moving object passing under the camera.
   c. The camera shall provide a guard tour functionality, which allows the dome to automatically move between selected presets using an individual speed and viewing time for each preset.
   d. The camera shall be able to record a custom PTZ tour, operated using an input device such as a joystick, mouse or keyboard, and then use and recall this as a guard tour.
   e. The camera shall be able to detect and automatically follow moving objects in the cameras field of view.
   f. The camera shall provide On-screen directional indicator (OSDI) functionality.
   g. The camera shall be equipped with accurate high-speed pan-tilt functionality with 360° endless pan range and a 180° tilt range.

h. The camera shall provide pan and tilt speed between 0.05° - 450°/sec.

5. Event functionality

    a. The camera shall be equipped with an integrated event functionality, which can be trigged by:
        1) Video Motion Detection
        2) Live Stream Accessed
        3) Manual Trigger/Virtual Inputs
        4) Fan malfunctioning
        5) Casing Open
        6) Heater malfunctioning
        7) Temperature
        8) PTZ functionality
        9) Embedded third party applications
        10) Edge storage disruption detection
        11) Shock Detected
    b. The cameras response to a trigged event shall include:
        1) Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
        2) Send images, using FTP, HTTP, HTTPS, network share or email
        3) Send video clip, using FTP, HTTP, HTTPS, network share or email
        4) Recording to local storage and/or network attached storage
        5) Day/Night Vision Mode

6. PTZ control functionality
    a. Overlay Text

7. Storage
    a. The camera shall be equipped with a video buffer for saving pre- and post-alarm images and shall have a SD card slot to support local storage of video.
    b. The camera shall support recording to network attached storage.

8. Security
    a. To secure access to the unit as well as provided content, the unit shall support HTTPS, SSL/TLS and IEEE802.1X authentication.
    b. The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
    c. The camera shall support IP address filtering and include at least three different levels of password security.

9. Product installation & maintenance
    a. The camera shall include a customizable pixel counter functionality, identifying the size of objects in number of pixels.
    b. The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
    c. The camera shall support time synchronization via NTP server.
    d. The camera shall provide a log file, containing information about all users connecting to the unit since last restart. The file shall include information about connecting IP address and the time of connecting.
    e. The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
    f. The camera shall send a notification when the unit has re-booted and all services are initialized.

10. API & applications
    a. The unit shall contain a built-in web server making video, audio and configuration available in a standard browser environment using HTTP.

b. The camera shall be fully supported by open and published API (Application Programmers Interface) providing necessary information for integration of functionality into third party applications.
c. Cameras shall comply with relevant ONVIF profile as defined by the ONVIF Organization.

11. Network functionality
    a. The camera shall support both static IP addresses and addresses from a DHCP-server.
    b. The camera shall support both IPv4 and IPv6.
    c. The camera shall incorporate support for Quality of Service (QoS).
    d. The camera shall incorporate support for Bonjour.

12. Other functionality
    a. The camera shall provide text overlay ability, including date and time.
    b. The camera shall have the ability to apply a graphical image as an overlay image in the video stream.
    c. The camera shall have the ability to provide up to 32 individual 3D privacy masks to the image.

B. EXTERIOR FIXED DOME NETWORK CAMERA

1. Make and Model: Axis Q3517-LVE, 5MP, WDR, multi-stream viewing (or approved equal)

2. General:
    a. The camera shall be manufactured with an IP66-, IP67-, IP6K9K- and NEMA 4X-rated, IK10+ (50 joules) impact-resistant casing.
    b. The camera shall be equipped with an IR-sensitive progressive scan megapixel sensor.
    c. The camera shall provide a manual 3-axis (pan/tilt/rotation) positioning to allow adjustment for optimum camera rotation and placement.
    d. The camera shall provide options for clear and smoked lower dome
    e. The camera shall provide remote zoom and remote focus functionality.
    f. The camera shall provide autorotation functionality.
    g. The camera shall provide redundancy between Power over Ethernet and DC power.
    h. The camera shall incorporate a function for Electronic Image Stabilization (EIS) for real-time image stabilization.
    i. The camera shall incorporate a function to manually correct barrel distortion, by using a slider to correct distortion in the image.
    j. The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in un-prioritized regions in order to lowering bandwidth and storage requirements.
    k. The specified unit shall be backed by a minimum of three years manufacturer warranty.
    l. The manufacturer shall provide the option of extended warranty for the unit. The optional extended warranty shall be available for a total warranty period of maximum five years.
    m. The specified unit shall be PVC-free.
    n. The contractor or designated subcontractor shall submit credentials of completed manufacturer certification, verified by a third party organization, as proof of the knowledge.

3. Lens
    a. Varifocal, 4.3-8.6 mm, F1.5
    b. Horizontal field of view: 96° – 50°
    c. Vertical field of view: 53° – 29°
    d. Remote focus and zoom, P-Iris control, IR corrected

4. Day and night
    a. Automatically removable infrared-cut filter

5. Minimum illumination 5MP 25/30 fps:
    a. Color: 0.12 lux at 50 IRE, F1.5
    b. B/W: 0.02 lux at 50 IRE, F1.5

c. 0 lux with IR illumination on
d. 4MP 50/60 fps:
e. Color: 0.24 lux at 50 IRE, F1.5
f. B/W; 0.04 lux at 50 IRE, F1.5
g. 0 lux with IR illumination on

6. Shutter time
   a. 1/71500 s to 2 s
7. Camera angle adjustment
   a. Pan: 360°
   b. Tilt: ±80°
   c. Rotation: ±175°
8. Video compression
   a. H.264 (MPEG-4 Part 10/AVC) Baseline, Main and High Profiles
   b. Motion JPEG
9. Resolution
   a. 3072x1728 to 160x120
10. Frame rate
    a. 5MP: 25/30 fps (50/60 Hz)
    b. 4MP: 50/60 fps (50/60 Hz)
11. Video streaming
    a. Multiple, individually configurable streams in H.264 and Motion JPEG
    b. Controllable frame rate and bandwidth
    c. VBR/MBR H.264
12. Multi-view streaming
    a. 8 individually cropped out view areas
13. Image settings
    a. Compression, Color, Brightness, Sharpness, Contrast, Local contrast, White balance, Exposure control (including automatic gain control), Defogging, Exposure zones, Fine tuning of behavior at different light levels, Forensic WDR: Up to 120 dB depending on scene, Electronic Image Stabilization, Barrel distortion correction, Dynamic text and image overlay, Privacy masks, Mirroring of images, Straighten image, Rotation: 0°, 90°, 180°, 270°, Auto, including corridor format
14. Pan/Tilt/Zoom
    a. Digital PTZ, Optical zoom, Preset positions
15. Audio streaming
    a. Two-way
16. Audio compression
    a. AAC LC 8/16/32/48 kHz, G.711, G.726 ADPCM 8kHz,
    b. Opus 8/16/48 kHz
    c. Configurable bitrate
17. Audio input/output
    a. External microphone input or line input, Line output
18. Security
    a. Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, digest authentication, user access log, centralized certificate management
19. Supported protocols

a. IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, SFTP, CIFS/SMB, SMTP, Bonjour, UPnP™, SNMP v1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH, LLDP

20. Application Programming Interface
    a. Open API for software integration
    b. ONVIF® Profiles S and G
21. Analytics
    a. Video motion detection, active tampering alarm
    b. Audio detection
    c. Support for installation of third-party applications
22. Event triggers: Analytics, Supervised external inputs, Virtual inputs through API,
23. Edge storage events, Shock detection
24. Event actions
    a. File upload via FTP, SFTP, HTTP, HTTPS, network share and email
    b. Notification via email, HTTP, HTTPS, and TCP
    c. External output activation, Pre- and post-alarm video buffering, Video and audio recording to edge storage, Play audio clip, Zoom preset, Overlay text, Send SNMP trap, Send video clip
25. Data streaming
    a. Event data
26. Built-in installation aids: Remote zoom, remote focus, pixel counter, leveling assistant, autorotation, straighten image
27. Casing: IP66-, IP67-, IP6K9K- and NEMA 4X-rated, IK10+ (50 joules) impact-resistant casing with polycarbonate hard coated dome, aluminum base and dehumidifying membrane
28. Encapsulated electronics, Captive screws
29. Color: White NCS S 1002-B
30. Sustainability PVC free
31. Memory: 1 GB RAM, 512 MB Flash
32. Power
    a. Power over Ethernet (PoE) IEEE 802.3af/802.3at Type 1 Class 3, typical 6.5 W, max 12.9W
    b. 8–28 V DC, typical 6.9 W, max 14.5 W
    c. Power redundancy
33. Connectors: RJ45 10BASE-T/100BASE-TX PoE, Terminal block for two configurable supervised inputs / digital outputs (12 V DC output, max. load 50 mA), 3.5 mm mic/line in, 3.5 mm line out, terminal block for DC input
34. IR illumination: IR LEDs (850 nm)
35. Range of reach: 40 m (130 ft)
36. Storage
    a. Support for microSD/microSDHC/microSDXC card
    b. Support for SD card encryption
    c. Support for recording to network-attached storage
    d. (NAS)
37. Operating conditions
    a. -50 °C to 60 °C (-58 °F to 140 °F)
    b. Humidity 10–100% RH (condensing)

38. Approvals
    a. EMC
    b. EN 55032 Class A, EN 50121-4, IEC 62236-4
    c. EN 55024, IEC/EN 61000-6-1
    d. IEC/EN 61000-6-2, FCC Part 15, Subpart B, Class A
    e. ICES-003 Class A, VCCI Class A
    f. RCM AS/NZS CISPR 22 Class A
    g. KCC KN32 Class A, KN35
    h. Safety
    i. IEC/EN/UL 60950-1, IEC/EN/UL 60950-22
    j. IEC/EN 62471
    k. Environment
    l. IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6
    m. IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-78
    n. NEMA 250 Type 4X, IEC/EN 62262 IK10+ (50J),
    o. ISO 20653 IP6K9K, IEC/EN 60529 IP66/67

39. Weight: 2.0 kg (4.4 lb) including weathershield

40. Dimensions
    a. Height: 182 mm including weathershield
    b. ø: 183.4 mm

C. INTERIOR FIXED DOME NETWORK CAMERA, 5MP

1. AXIS Q3517-LV
    a. The camera shall be manufactured with an IP66-, IP67-, IP6K9K- and NEMA 4X-rated, IK10+ (50 joules) impact-resistant casing.
    b. The camera shall be equipped with an IR-sensitive progressive scan megapixel sensor.
    c. The camera shall provide a manual 3-axis (pan/tilt/rotation) positioning to allow adjustment for optimum camera rotation and placement.
    d. The camera shall provide options for clear and smoked lower dome
    e. The camera shall provide remote zoom and remote focus functionality.
    f. The camera shall provide autorotation functionality.
    g. The camera shall provide redundancy between Power over Ethernet and DC power.
    h. The camera shall incorporate a function for Electronic Image Stabilization (EIS) for real-time image stabilization.
    i. The camera shall incorporate a function to manually correct barrel distortion, by using a slider to correct distortion in the image.
    j. The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.
    k. The specified unit shall be backed by a minimum of three years manufacturer warranty.
    l. The manufacturer shall provide the option of extended warranty for the unit. The optional extended warranty shall be available for a total warranty period of maximum five years.
    m. The specified unit shall be PVC-free.
    n. The contractor or designated subcontractor shall submit credentials of completed manufacturer certification, verified by a third party organization, as proof of the knowledge.

2. Lens
    a. Varifocal, 3-9 mm, F1.5
    b. Horizontal field of view: 96° – 50°
    c. Vertical field of view: 53° – 29°
    d. Remote focus and zoom, P-Iris control, IR corrected

3. Day and night
    a. Automatically removable infrared-cut filter

4. Minimum illumination
    a. 5MP 25/30 fps:
    b. Color: 0.12 lux at 50 IRE, F1.5
    c. B/W: 0.02 lux at 50 IRE, F1.5
    d. 0 lux with IR illumination on
    e. 4MP 50/60 fps:
    f. Color: 0.24 lux at 50 IRE, F1.5
    g. B/W; 0.04 lux at 50 IRE, F1.5
    h. 0 lux with IR illumination on
5. Shutter time: 1/71500 s to 2 s
6. Camera angle adjustment
    a. Pan: 360°
    b. Tilt: ±80°
    c. Rotation: ±175°
7. Video compression
    a. H.264 (MPEG-4 Part 10/AVC) Baseline, Main and High Profiles
    b. Motion JPEG
8. Resolution: 3072x1728 to 160x120
9. Frame rate
    a. 5MP: 25/30 fps (50/60 Hz)
    b. 4MP: 50/60 fps (50/60 Hz)
10. Video streaming
    a. Multiple, individually configurable streams in H.264 and Motion JPEG
    b. Controllable frame rate and bandwidth
    c. VBR/MBR H.264
11. Multi-view streaming: 8 individually cropped out view areas
12. Image settings: Compression, Color, Brightness, Sharpness, Contrast, Local contrast, White balance, Exposure control (including automatic gain control), Defogging, Exposure zones, Fine tuning of behavior at different light levels, Forensic WDR: Up to 120 dB depending on scene, Electronic Image Stabilization, Barrel distortion correction, Dynamic text and image overlay, Privacy masks, Mirroring of images, Straighten image, Rotation: 0°, 90°, 180°, 270°, Auto, including corridor format
13. Pan/Tilt/Zoom: Digital PTZ, Optical zoom, Preset positions
14. Audio streaming: Two-way
15. Audio compression
    a. AAC LC 8/16/32/48 kHz, G.711, G.726 ADPCM 8kHz,
    b. Opus 8/16/48 kHz
    c. Configurable bitrate
16. Audio input/output: External microphone input or line input, Line output
17. Security: Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, digest authentication, user access log, centralized certificate management
18. Supported protocols: IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, SFTP, CIFS/SMB, SMTP, Bonjour, UPnP™, SNMP v1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH, LLDP
19. Application Programming Interface
    a. Open API for software integration

b. ONVIF® Profiles S and G

20. Analytics
    a. Video motion detection, active tampering alarm,
    b. Audio detection
    c. Support for installation of third-party applications
21. Event triggers: Analytics, Supervised external inputs, Virtual inputs through API, Edge storage events, Shock detection
22. Event actions: File upload via FTP, SFTP, HTTP, HTTPS, network share and email Notification via email, HTTP, HTTPS, and TCP External output activation, Pre- and post-alarm video buffering, Video and audio recording to edge storage, Play audio clip, Zoom preset, Overlay text, Send SNMP trap, Send video clip
23. Data streaming Event data
24. Built-in installation aids Remote zoom, remote focus, pixel counter, leveling assistant, autorotation, straighten image
25. Casing:
    a. IP66-, IP67-, IP6K9K- and NEMA 4X-rated, IK10+ (50 joules) impact-resistant casing with polycarbonate hard coated dome, aluminum base and dehumidifying membrane Encapsulated electronics, Captive screws
    b. Color: White NCS S 1002-B
26. Sustainability: PVC free
27. Memory: 1 GB RAM, 512 MB Flash
28. Power
    a. Power over Ethernet (PoE) IEEE 802.3af/802.3at Type 1 Class 3, typical 6.5 W, max 12.9W
    b. 8–28 V DC, typical 6.9 W, max 14.5 W
    c. Power redundancy
29. Connectors: RJ45 10BASE-T/100BASE-TX PoE, Terminal block for two configurable supervised inputs / digital outputs (12 V DC output, max. load 50 mA), 3.5 mm mic/line in, 3.5 mm line out, terminal block for DC input
30. IR illumination:
    a. IR LEDs (850 nm)
    b. Range of reach 40 m (130 ft)
31. Storage Support
    a. MicroSD/microSDHC/microSDXC card
    b. Support for SD card encryption
    c. Support for recording to network-attached storage
    d. (NAS)
32. Operating conditions
    a. -50 °C to 60 °C (-58 °F to 140 °F)
    b. Humidity 10–100% RH (condensing)
33. Approvals
    a. EMC
    b. EN 55032 Class A, EN 50121-4, IEC 62236-4
    c. EN 55024, IEC/EN 61000-6-1
    d. IEC/EN 61000-6-2, FCC Part 15, Subpart B, Class A
    e. ICES-003 Class A, VCCI Class A
    f. RCM AS/NZS CISPR 22 Class A
    g. KCC KN32 Class A, KN35

h. Safety
i. IEC/EN/UL 60950-1, IEC/EN/UL 60950-22
j. IEC/EN 62471
k. Environment
l. IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6
m. IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-78
n. NEMA 250 Type 4X, IEC/EN 62262 IK10+ (50J),
o. ISO 20653 IP6K9K, IEC/EN 60529 IP66/67

34. Weight: 2.0 kg (4.4 lb) including weathershield

35. Dimensions Height:
    a. 182 mm including weathershield
    b. ø: 183.4 mm

D. 360° SITUATIONAL AWARENESS WITH X32 PTZ, AXIS Q6000/Q6055 MK II

1. Sensors & optics
    a. The camera shall incorporate 4x HDTV 720p cameras, providing full 360° overview.
    b. The camera shall meet or exceed the following illumination specifications:
        1) 0.3 lux, F2.0

2. Image Control

    a. The unit shall incorporate Automatic and Manual White Balance.
    b. The camera shall incorporate an electronic shutter operating in the range of 1/45500s to 4s.
    c. The camera shall provide backlight compensation.
    d. The camera shall incorporate a function for optimization of low light behavior.

3. Video
    a. The camera shall provide simultaneous Motion JPEG and H.264 video streams.
    b. The camera shall be designed to provide video streams in:
        1) 1280x720 (HDTV 720p) 25/30 fps 50/60 Hz
        2) 1920x1440 (Quad view)
    c. The camera shall support H.264 Baseline, Main and High Profile.
    d. The H.264 implementation shall include both unicast and multicast functionality and support Maximum Bit Rate (MBR).
    e. The camera shall support H.264 with automatic scene adaptive bitrate control.
    f. The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.

4. Event functionality
    a. The camera shall be equipped with an integrated event functionality, which can be trigged by:
        1) Video Motion Detection
        2) Live Stream Accessed
        3) Camera tampering
        4) Fan Malfunctioning
        5) Manual Trigger/Virtual Inputs
        6) Embedded third party applications
        7) Edge storage disruption detection
        8) Shock Detected
    b. The cameras response to a trigged event shall include:
        1) Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
        2) Send images, using FTP, HTTP, HTTPS, network share or email
        3) Send video clip, using FTP, HTTP, HTTPS, network share or email
        4) Recording to local storage and/or network attached storage

5) Send SNMP trap message
6) Recording to local storage and/or network attached storage
7) Overlay Text

5. Storage
   a. The camera shall be equipped with a video buffer for saving pre- and post-alarm images and shall have a SD-card slot to support local storage of video.
   b. The camera shall support recording to network attached storage.
6. Security
   a. To secure access to the unit as well as provided content, the unit shall support HTTPS, SSL/TLS and IEEE802.1X authentication.
   b. The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
   c. The camera shall support IP address filtering and include at least three different levels of password security.
7. Product installation & maintenance
   a. The camera shall include a customizable pixel counter functionality, identifying the size of objects in number of pixels.
   b. The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
   c. The camera shall support time synchronization via NTP server.
   d. The camera shall provide a log file, containing information about all users connecting to the unit since last restart. The file shall include information about connecting IP address and the time of connecting.
   e. The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
   f. The camera shall send a notification when the unit has re-booted and all services are initialized.
8. API & applications
   a. The unit shall contain a built-in web server making video, audio and configuration available in a standard browser environment using HTTP.
   b. The camera shall be fully supported by open and published API (Application Programmers Interface) providing necessary information for integration of functionality into third party applications.
   c. Cameras shall comply with relevant ONVIF profile as defined by the ONVIF Organization.
9. Network functionality
   a. The camera shall support both static IP addresses and addresses from a DHCP-server.
   b. The camera shall support both IPv4 and IPv6.
   c. The camera shall incorporate support for Quality of Service (QoS).
   d. The camera shall incorporate support for Bonjour.
10. Other functionality
   a. The camera shall provide text overlay ability, including date and time.
   b. The camera shall have the ability to apply a graphical image as an overlay image in the video stream.
   c. The camera shall provide the ability to apply privacy masks to the image.
11. Mechanics & environmental
   a. The camera shall be manufactured with an IP66- and NEMA 4X-rated, die-casted aluminum casing.
   b. The camera shall be designed to be compatible with any AXIS Q60-E model.
   c. The camera shall be manufactured with exchangeable and tilt able lenses.

d. The camera shall operate in a temperature range of -30 °C to 50 °C (-22 °F to 122 °F).
e. The camera shall operate in a Maximum temperature of 60 °C (140 °F) (intermittent).
f. The camera shall operate in a humidity range of 10-100% RH (condensing).

12. Connectors
    a. The camera shall be equipped with a RJ45 10BASE-T/100BASE-TX/1000BASE-T PoE Ethernet port.
    b. The camera shall be equipped with a spare RJ45 10BASE-T/100BASE-TX socket for auxiliary Ethernet connection.
    c. The camera shall be equipped with a RJ45 10BASE-T/100BASE-TX connection port for interconnection with Q60-E camera.

13. Power

    a. 100-240 VAC / 50-60 Hz, max 60 W – provided to the camera through the network cable by a separate injector, supplied with the camera.
        1) Max: 18 W
        2) Typical: 8 W

14. Standards & Regulations
    a. The specified unit shall meet product safety standards as defined in IEC/EN/UL 60950-1
    b. The specified unit shall meet product safety standards as defined in IEC/EN/UL 60950-22
    c. The camera shall meet relevant parts of SMPTE 296M (HDTV 720p)
    d. The camera shall meet ISO/IEC 14496-10 Advanced Video Coding (H.264)
    e. The specified unit shall carry the following EMC approvals:
        1) EN 55032 Class A
        2) EN 55024
        3) FCC Part 15 - Subpart A
        4) VCCI Class A
        5) RCM AS/NZS CISPR 22 Class A
        6) ICES-003 Class A
        7) KCC KN22 Class A
        8) KN24
    f. The camera shall meet the following mechanical environmental standards:
        1) IEC/EN 60529 IP66
        2) IEC/EN 62262 IK10
        3) NEMA 250 Type 4X
        4) IEC 60068-2-1
        5) IEC 60068-2-2
        6) IEC 60068-2-6
        7) IEC 60068-2-14
        8) IEC 60068-2-27
        9) IEC 60721-4-3 Class 4K3, 4M3
    g. The camera shall meet the following railway environmental standards:
        1) EN 50121-4
        2) IEC 62236-4
    h. The camera shall meet the following standards:
        1) IEEE 802.1X (Authentication)
        2) IPv4 (RFC 791)
        3) IPv6 (RFC 2460)
        4) QoS – DiffServ (RFC 2475)

15. Sustainability
    a. The specified unit shall be manufactured in accordance with ISO 14001.
    b. The specified unit shall be compliant with the EU directives 2011/65/EU (RoHS) and 2012/19/EU (WEEE).
    c. The specified unit shall be compliant with the EU regulation 1907/2006 (REACH).

d. The specified unit shall be PVC-free in accordance with IEC 61249-2-21.
e. The manufacturer shall have signed and support the UN Global Compact initiative as defined by United Nations https://www.unglobalcompact.org/

16. Installation, Warranty & Recognitions
    a. The specified unit shall be backed by a minimum of three years manufacturer warranty.
    b. The manufacturer shall provide the option of extended warranty for the camera. The optional extended warranty shall be available in two-year extension blocks for a total warranty period of maximum five years.
    c. The contractor or designated subcontractor shall submit credentials of completed manufacturer certification, verified by a third party organization, as proof of the knowledge.
    d. All equipment shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.
    e. All firmware found in products shall be the latest and most up-to-date provided by the manufacturer, or of a version as specified by the provider of the Video Management Application (VMA) or Network Video Recorder (NVR).

E. 360° CAMERA-Lobby entrance, Small Rooms, Storage, Service Rooms:

1. Make and Model: Axis M3057-PLVE
    a. 6 MP outdoor-ready dome network camera

2. The network camera shall meet or exceed the following design specifications:
    a. The camera shall operate on an open source and Linux-based platform, and include a built-in web server.
    b. The camera shall be equipped with a progressive scan megapixel sensor.
    c. The camera shall provide a removable IR-cut filter, providing day/night functionality.
    d. The camera shall be factory-focused, which removes the need for manual focusing.
    e. The camera shall be manufactured with a paintable casing.
    f. The camera shall provide local video storage utilizing a microSD/microSDHC/microSDXC memory card expansion.
    g. The camera shall be manufactured with an IP66-, NEMA 250 4X-rated and IK-10 impact-resistant casing with polycarbonate and aluminum hard-coated dome.

3. The network camera shall meet or exceed the following performance specifications:
    a. Illumination

4. The camera shall meet or exceed the following illumination specifications:
    a. Color: 0.16 lux at 50 IRE F2.0
    b. B/W: 0.03 lux at 50 IRE F2.0
    c. 0 lux with IR illumination on

5. Resolution
    a. The camera shall be designed to provide at multiple, individually configurable streams in H.264 and Motion JPEG.
    b. The camera shall support 360° overview, de-warped panorama, double panorama, corridor and quad views. Up to four individually cropped out and de-warped view areas. The 360° overview can be streamed simultaneously with four view areas or one other de-warped view.
    c. The camera shall support video resolutions including:
        1) Overview: 2048x2048 to 160x160
        2) Panorama: 2560x960 to 192x72
        3) Double Panorama: 2560x1920 to 256x144
        4) Quad view: 2560x1920 to 256x144
        5) View area 1-4, 16:9: 2048x1152 to 256x144, 4:3: 1920x1440 to 320x240
        6) Panorama corner left or right: 2368x1184 to 192x72
        7) Double panorama corner: 2048x2048 to 320x240
        8) Corridor: 2560x1920 to 256x144

6. The camera shall provide both landscape format (4:3 and 16:9 aspect ratio) as well as corridor format (3:4 and 9:16 aspect ratio).
    a. Encoding
7. The camera shall support the following video encoding algorithms:
    a. Motion JPEG encoding with WDR in a selectable range from 1 up to 25/30 frames per second in 360° overview and de-warped views.
    b. Motion JPEG encoding without WDR in a selectable range from 1 up to 50/60 frames per second in 360° overview.
    c. Baseline Profile H.264 encoding with motion estimation.
    d. Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC).
    e. High Profile H.264 encoding with motion estimation.
8. The camera shall provide independently configured simultaneous H.264 and Motion JPEG streams.
9. The camera shall in H.264 support Variable Bit Rate (VBR) for video quality adapted to scene content. To protect the network from unexpected bit rate speaks the camera shall support Maximum Bit Rate (MBR).
10. The camera shall provide configurable compression levels.
11. The camera shall support standard baseline profile H.264 with motion estimation.
12. The camera shall support motion estimation in H.264/MPEG-4 Part 10/AVC.
13. The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.
    a. Transmission
14. The camera shall allow for video to be transported over:
    a. HTTP (Unicast)
    b. HTTPS (Unicast)
    c. RTP (Unicast & Multicast)
    d. RTP over RTSP (Unicast)
    e. RTP over RTSP over HTTP (Unicast)
    f. SRTP (Unicast & Multicast)
15. The camera shall support Quality of Service (QoS) to be able to prioritize traffic.
    a. Image
16. The camera shall incorporate automatic and manual white balance.
17. The camera shall incorporate an electronic shutter operating in the range of 1/100000 s to 2 s.
18. The camera shall incorporate forensic wide dynamic range functionality, providing up to 120 dB dynamic range.
19. The camera shall support manually defined values for:
    a. Color level
    b. Brightness
    c. Sharpness
    d. Contrast
20. The camera shall allow for rotation of the image.
    a. IR Illumination
        1) The camera shall be equipped with built-in IR LEDs.
        2) The IR LEDs shall have a range of up to 20 m (66 ft)
        3) The IR LEDs shall emit light with a wavelength of 850 nm.
    b. User Interface

21. Web server
    a. The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.
    b. Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.

22. Language Specification
    a. The camera shall provide a function for altering the language of the user interface, and shall include support for at least 10 different languages.

23. IP addresses
    a. The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.
    b. The camera shall allow for automatic detection of the camera based on UPnP and Bonjour when using a computer with an operating system supporting this feature.
    c. The camera shall provide support for both IPv4 and IPv6.

24. PTZ functionality
    a. The camera shall:
        1) Provide digital PTZ functionality of view areas.
        2) Provide preset positions functionality.
        3) Provide digital pan (except panorama at wall mount) and tilt of panorama, corner, corridor and quad views.
        4) Provide a guard tour functionality which allows the dome to automatically move between selected presets using an individual speed and viewing time for each preset.

25. Event functionality
    a. The camera shall be equipped with an integrated event functionality, which can be trigged by:
        1) Video Motion Detection
        2) Camera tampering
        3) Manual Trigger/Virtual Inputs
        4) PTZ functionality
        5) Embedded third party applications
        6) Edge storage fail-over recording detection

26. Response to triggers shall include event actions:
    a. Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
    b. Send images, using FTP, SFTP, HTTP, HTTPS, network share or email
    c. Send video clip, using FTP, SFTP, HTTP, HTTPS, network share or email
    d. Send SNMP trap message
    e. Recording to local storage and/or network attached storage
    f. Activate external output
    g. PTZ control functionality
    h. WDR mode
    i. Day and night mode

27. The camera shall provide memory for pre & post alarm recordings.
    a. Edge storage
    b. The camera shall support continuous and event controlled recording to:
    c. Local memory added to the cameras microSD-card slot
    d. Network attached storage, located on the local network
    e. The camera shall incorporate encryption functionality for the SD card.
    f. The camera shall be able to detect and notify edge storage disruptions.

28. Protocol

a. The camera shall incorporate support for at least IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, SFTP, CIFS/SMB, SMTP, Bonjour, UPnP, SNMP v1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, SRTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH, LLDP, HDMI 1.4.
b. The SMTP implementation shall include support for SMTP authentication.

29. Text overlay
    a. The camera shall:
        1) Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
        2) Provide the possibility to choose different font sizes for embedded on-screen text, and to use white or black text on at least four different backgrounds.
        3) Provide the ability to manually set up and configure privacy masks to the image.
        4) Allow for the overlay of a graphical image, such as a logotype, into the image.

30. Security
    a. The camera shall support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.
    b. The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
    c. The camera shall support IEEE 802.1X authentication.
    d. The camera shall provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
    e. The camera shall restrict access to the built-in web server by usernames and passwords at three different levels.

31. API support
    a. The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.
    b. The camera shall conform to ONVIF profile G as defined by the ONVIF Organization.
    c. The camera shall conform to ONVIF profile S as defined by the ONVIF Organization.
    d. For ONVIF profile specifications, see www.onvif.org/

32. Embedded applications
    a. The camera shall provide a platform allowing the upload of third party applications into the camera.

33. Installation and maintenance
    a. The camera shall be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the cameras' configuration.
    b. The camera shall support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
    c. The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
    d. The camera shall provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
    e. The camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
    f. The camera shall store all customer-specific settings in a non-volatile memory that shall not be lost during power cuts or soft reset.

34. Access log

a. The camera shall provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
b. The camera shall provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.

35. Camera diagnostics
    a. The camera shall be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.
    b. The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
    c. The camera shall send a notification when the unit has re-booted and all services are initialized.

36. Hardware interfaces
    a. Network interface
        1) The camera shall be equipped with one 10BASE-T/100BASE-TX Fast Ethernet-port using a RJ45 connector, and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex).
    b. Inputs/Outputs
        1) The camera shall be equipped with one supervised (alarm) input and one digital output, accessible via a removable terminal block. This input shall be configurable to respond to normally open (NO) or normally closed (NC) dry contacts. The output shall be able to provide 12 V DC, 25 mA.
    c. Enclosure
        1) The camera shall:
        2) Be manufactured with an IP66, NEMA 4X and IK10 impact-resistant casing in polycarbonate and aluminum.
        3) Be fitted with a dehumidifying membrane.
    d. Power
        1) The camera shall provide power over Ethernet IEEE 802.3af/802.3at Type 1 Class 3
            1. Max: 12.95 W
            2. Typical: 7.7 W

37. Environmental
    a. The camera shall:
        1) Operate in a temperature range of -40 °C to 50 °C (-40 °F to 122 °F)
        2) Operate in a maximum temperature (intermittent) of 55 °C (131 °F)
        3) Operate in a humidity range of 10–100% RH (condensing).

38. 360° CAMERA-Elevators Only:
    a. Make and Model: ONCAM Mini Recessed Camera EVO-05-LRD
    b. Mobotix MX-Q25M-SEC-DN, or Better

39. Environmental Factors:
    a. Operating temperatures:
        1) -30°C to 60°C (-22°F to 140˚F)

40. Power Requirements:
    a. Power over Ethernet IEEE 802.3af
    b. PoE class varies with operation
    c. Power consumption: approx. 4.5W

41. Mounting:
    a. Elevator cab ceiling mount MX-OPT-IC-PW

42. Interface:
    a. RJ-45 10 BASE-T/100BASE-TX PoE
    b. USB

43. Salient Characteristics
    a. Camera:
        1) Image sensor: 1/2" CMOS, progressive scan
        2) Lens: L11 (hemispherical), L22 (90˚ x 67˚)
        3) Min. Illumination: Color: 1 lux (t=1/60 sec.), 0.05 lux (t=1/1 sec)
        4) Video:
            a) Compression
            b) MxPEG
            c) Motion JPEG
            d) JPG
            e) H.263 (video – VoIP - telephony)
        5) Resolution:
            a) 2048 x 1536 (3MP)
        6) Frame Rate:
            a) VGA: 22 fps
            b) TV-PAL: 18 fps
            c) Mega: 8 fps
            d) 3MP: 4 fps
        7) Video Streaming:
            a) VGA: 30 fps
            b) TV-PAL: 30 fps
            c) Mega: 30 fps
            d) 3MP: 20 fps
        8) Pan-tilt-zoom:
            a) Digital, continuous 8x zoom
    b. Network:
        1) Security:
            a) User-/Group management
            b) IP address filtering
            c) HTTPS/SSL
            d) IEEE 802.1X network access control
            e) Intrusion detection
            f) Digital image signature
        2) System integration:
            a) Application Programming Interface
            b) Inclusive video management software MxEasy
        3) Alarm/Events
            a) Integrated multiple-window motion detection
            b) Temperature sensor
            c) Notification via e-mail, FTP, IP-Telephony (VoIP, SIP)
            d) Visual/acoustic alarm
            e) Pre- and post-alarm images
    c. General
        1) Memory:
            a) Internal 64 MB image memory
        2) Local edge storage:
            a) MicroSD slot
        3) Included accessories
            a) Installation manual
            b) Software
            c) 4 GB MicroSD
            d) Mounting parts

e) Patch cable
4) Casing
a) High-resistant composites – PBT-PC
b) Color: white
5) Edge Storage:
a) Micro SD memory card slot

44. Warranty:
a. 1-year

F. THERMAL CAMERAS:

1. Make/Model: Make/Model: Axis Q1942-E 10 mm/19 mm/35 mm or 60 mm

2. Sensors & optics
a. The camera shall use an Uncooled Microbolometer with a FPA Format of 640x480 and 17µm pixel size.
b. The camera shall be available in at least 4 different versions, providing horizontal field of views between 10º and 63º.
c. The camera shall provide a NetD sensitivity of less than 50mK.

3. Image Control
a. The camera shall provide at least 8 different palettes used to improve the detection of information in the video.
b. The camera shall allow for rotation of the image in steps of 90º.
c. The camera shall incorporate a function for Electronic Image Stabilization (EIS) for real-time image stabilization.

4. Video
a. The camera shall provide simultaneous Motion JPEG and H.264 video streams.
b. The camera shall be designed to provide a native thermal video stream of 640x480 pixels resolution at 8.3 frames per second using H.264 or Motion JPEG and shall provide NetD sensitivity below 50 mK.
c. The camera shall be designed to provide a native thermal video stream of 640x480 pixels resolution at 30 frames per second using H.264 or Motion JPEG and shall provide NetD sensitivity below 50 mK.
d. The camera shall support video resolutions including:
1) 640x480 (native resolution)
2) 800x600 (scaled)
e. The camera shall provide both landscape format (4:3 and 16:9 aspect ratio) as well as corridor format (3:4 and 9:16 aspect ratio).
f. The camera shall support H.264 Baseline, Main and High Profile.
g. The H.264 implementation shall include both unicast and multicast functionality and support maximum Bit Rate (MBR) as well as Variable Bit Rate (VBR).
h. The camera shall support H.264 with automatic scene adaptive bitrate control.
i. The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in un-prioritized regions in order to lowering bandwidth and storage requirements.

5. Audio
a. The camera shall provide two-way full duplex audio
b. Input sources:
1) External microphone
2) External line device
c. Output sources
1) External line device
d. The camera shall support the following encodings:
1) AAC LC at 8/16 kHz

2) G.711 PCM at 8 kHz
3) G.726 ADPCM at 8 kHz

6. Mechanics & environmental
   a. The camera shall be manufactured with an IP66-, IP67- and NEMA 4X-rated metal casing (aluminum).
   b.
   c. The camera shall be manufactured with a heated protective window for protection of the lens and to enable deicing.
   d.
   e. The camera shall operate in a temperature range of -40°C to +60°C (-40°F to +140°F).
   f.
   g. The camera shall operate in a humidity range of 10-100% RH (condensing).
7. Connectors
   a. The camera shall be equipped with a RJ45 10BASE-T/100BASE-TX PoE Ethernet port.
   b.
   c. The camera shall, by using a “multi wire cable”, provide connectivity for:
      1) Two digital I/O(alarm) ports. Configurable as input or output
      2) One line/mic input and one line out.
      3) AC power
      4) DC power
8. Event functionality
   a. The camera shall be equipped with an integrated event functionality, which can be trigged by:
      1) Video Motion Detection
      2) Audio Detection
      3) Live Stream Accessed
      4) Manual Trigger/Virtual Inputs
      5) External input
      6) Embedded third party applications
      7) Edge storage disruption detection
      8) Shock Detected
   b. The cameras response to a trigged event shall include:
      1) Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
      2) Send images, using FTP, HTTP, HTTPS, network share or email
      3) Send video clip, using FTP, HTTP, HTTPS, network share or email
      4) Send SNMP trap message
      5) Recording to local storage and/or network attached storage
      6) Activating external output
      7) Play audio clip
      8) Text Overlay
9. Storage
   a. The camera shall be equipped with a video buffer for saving pre- and post-alarm images and shall have a microSD-card slot to support local storage of video.
   b. The camera shall support recording to network attached storage.
10. Security
    a. To secure access to the unit as well as provided content, the unit shall support HTTPS, SSL/TLS and IEEE802.1X authentication.
    b. The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
11. Installation and maintenance

a. The camera shall include a customizable pixel counter functionality, identifying the size of objects in number of pixels.
b. The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
c. The camera shall support time synchronization via NTP server.
d. The camera shall provide a log file, containing information about all users connecting to the unit since last restart. The file shall include information about connecting IP address and the time of connecting.
e. The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
f. The camera shall send a notification when the unit has re-booted and all services are initialized.

12. Other functionality
    a. The camera shall provide text overlay ability, including date and time.
    b. The camera shall have the ability to apply a graphical image as an overlay image in the video stream.
    c. The camera shall provide the ability to apply privacy masks to the image.
13. Network functionality
    a. The camera shall support both static IP addresses and addresses from a DHCP-server.
    b. The camera shall support both IPv4 and IPv6.
    c. The camera shall incorporate support for Quality of Service (QoS).
    d. The camera shall incorporate support for Bonjour.
    e. The camera shall support IP address filtering and include at least three different levels of password security.
14. Power
    a. Power over Ethernet IEEE 802.3af/802.3at Type 1 Class 3
        1) Max 11.8 W
        2) Typical 4.8 W
    b. 8 - 28 V DC
        1) Max 13 W
        2) Typical 6.6 W
    c. 20 - 24 V AC
        1) Max 19 VA
        2) Typical 11 VA
15. API & applications
    a. The unit shall contain a built-in web server making video, audio and configuration available in a standard browser environment using HTTP.
    b. The camera shall be fully supported by open and published API (Application Programmers Interface) providing necessary information for integration of functionality into third party applications.
    c. Cameras shall comply with relevant ONVIF profile as defined by the ONVIF Organization.
16. Standards & Regulations
    a. The specified unit shall meet product safety standards as defined in IEC/EN/UL 60950-1
    b. The specified unit shall meet product safety standards as defined in IEC/EN/UL 60950-22
    c. The camera shall meet ISO/IEC 14496-10 Advanced Video Coding (H.264)
    d. The specified unit shall carry the following EMC approvals:
        1) EN 55022 Class A
        2) EN 55024
        3) FCC Part 15 - Subpart A
        4) VCCI Class A
        5) RCM AS/NZS CISPR 22 Class A
        6) ICES-003 Class A
        7) KCC KN32 Class A

8) KN35
9) The camera shall meet the following mechanical environmental standards:
10) IEC 60529 IP66/IP67
11) NEMA 250 Type 4X
12) IEC 60068-2-1
13) IEC 60068-2-2
14) IEC 60068-2-6 Class 4M4
15) IEC 60068-2-27
16) IEC 60068-2-52
17) IEC 60721-3-4 Class 4K3
18) EN 50581

e. The camera shall meet the following railway environmental standards:
1) EN 50121-4
2) IEC 62236-4

f. The camera shall meet the following standards:
1) IEEE 802.3af/802.3at (Power over Ethernet)
2) IEEE 802.1X (Authentication)
3) IPv4 (RFC 791)
4) IPv6 (RFC 2460)
5) QoS – DiffServ (RFC 2475)

17. Installation, Warranty & Recognitions

a. The specified unit shall be backed by a minimum of three years manufacturer warranty.
b. The manufacturer shall provide the option of extended warranty for the camera. The optional extended warranty shall be available in two-year extension blocks for a total warranty period of maximum five years.
c. The contractor or designated subcontractor shall submit credentials of completed manufacturer certification, verified by a third party organization, as proof of the knowledge.
d. All equipment shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.
e. All firmware found in products shall be the latest and most up-to-date provided by the manufacturer, or of a version as specified by the provider of the Video Management Application (VMA) or Network Video Recorder (NVR).

G. PERIPHERAL PoE NETWORK SWITCHES, HARDENED, SMALL FORM FACTOR: Refer to Section 27 06 05 Communications Standard Specifications-Equipment & Material

H. MEDIA CONVERTERS (Standard POE CAT6 to Fiber):

1. Make/Model: Comnet CWFE1002BPOE/M

2. Environmental Factors:
a. Operating Temperatures:
1) -40˚C to 75˚C (-40˚F to 167˚F)
b. Operating and Storage Humidity:
1) 10-95% RH (non-condensing)

3. Power Requirements:
a. 48 V DC max. 1.25 A

4. Dimensions:
a. 4.0 × 3.7 × 1.0 in (10.4 × 9.5 × 2.7 cm)

5. Mounting:
a. DIN Rail

6. Interface:

a. 2 (two) RJ45 connectors (10/100 Mbps)
b. 2 (two) SFP connectors (100/1000 Mbps) for SFP fiber optic modules or SFP to copper modules
c. 1x power

7. Salient Characteristics:
   a. Display and Indicators:
      1) Power LED indicator; Network LED indicator (4x)
   b. Compliance:
      1) RoHS, REACH, WEEE, CE, EN 50022, IEC 60715, AS 2756
   c. Approvals:
      1) EN 55022 Class A, EN 61000-3-2, EN 61000-3-3, EN 61000-6-1, EN 61000-6-2, EN 55024, FCC Part 15 Subpart B Class A, ICES-003 Class A, VCCI Class A, C-tick AS/NZS CISPR 22, KCC KN22 Class A, KN24, IEC/EN 60950-1
   d. Warranty:
      1) Lifetime

I. MEDIA CONVERTERS (60W POE CAT6 to Fiber):

1. Make/Model: Comnet CNFE200(X)(M,S)(1,2)[POE][HO][/M] Series

2. Environmental Factors:
   a. Operating Temperatures:
      1) -40˚C to 75˚C (-40˚F to 167˚F)
   b. Operating and Storage Humidity:
      1) 10-95% RH (non-condensing)

3. Power Requirements:
   a. 48 V DC max. 1.25 A

4. Dimensions:
   a. 4.0 × 3.7 × 1.0 in (10.4 × 9.5 × 2.7 cm)

5. Mounting:
   a. DIN Rail

6. Interface:
   a. 2 (two) RJ45 connectors (10/100 Mbps)
   b. 2 (two) SFP connectors (100/1000 Mbps) for SFP fiber optic modules or SFP to copper modules
   c. 1x power

7. Salient Characteristics:
   a. Display and Indicators:
      1) Power LED indicator; Network LED indicator (4x)
   b. Warranty:
      1) Lifetime

J. MEMORY CARDS:

1. Make and model:
   a. Sandisk Extreme Plus 32GB UHS-1/U3 SDHC or approved equivalent
   b. Sandisk Extreme Plus 32GB microSDHC UHS-1/U3 or approved equivalent

2. Up to 80MB/s read Speed

3. Class 10 For Full 1080p HD Video

4. Compatibility: SDHC, SDXC, SDHC UUHS-I and SDXC-I Supporting Devices

5. Lifetime limited warranty

6. Waterproof, x-ray Proof, temperature and shockproof

K. Surge Protector:

1. Make and Model: Ports Systems 606 CAT6 Surge Protector, Building Entrance Protection that maintains CAT 6 performance

2. UL 497, 497A and UL 497B listed for Primary, Secondary, and Isolated Loop Circuit Protection

3. Ultra-low capacitance solid state technology provides protection for frequencies up to 250 MHz

4. 110 termination

5. Cover included

6. Designed for use in enclosure

7. Available with factory installed solid state protector modules for 18V, 27V or 65V

8. Ideal for using Power Over Ethernet (PoE) circuit protection using 65 volt module

9. ISO 9001:2000 registered facility

10. Operating Temperature: -13˚F to 149˚F (-25˚C to 65˚C)

2.02 PREPARATION

A. Protection of In-Place Conditions:

1. Safety buriers shall be placed around all open manholes when open.

2. During revenue hours, in addition to the burier, a person shall be placed at the manhole opening.

B. Surface Preparation:

1. Prior to core drilling walls or floors for conduit paths, contractor shall X-ray or use GPR to ensure there are obstructions within the.

2. Prior to all core drilling WMATA shall be informed and areas identified on plans.

C. Demolition / Removal:

1. Old equipment remove shall be returned to WMATA via the Project Manager.

2. Conduit, wires and cable shall be removed with equipment.

3. Freed power panel breakers shall be indemnified on the panel schedule sleeve and in the As-Built drawings.

2.03 INSTALLATION

A. Installation of the camera system shall be performed in a neat and professional manner and retain all elements of the rail system's architectural excellence.

B. Installation of the camera system shall be coordinated with work of other trades.

C. CCTV equipment shall be installed in accordance with manufacturer's instructions. Deviations from manufactures instructions shall be approved by WMATA.

D. Within rail station passenger areas, CCTV cameras shall be installed a minimum of 9’-0” above finished floor (AFF). Outside the station cameras shall be installed a minimum of 12’-0” above grade level (AGL).

E. CCTV cameras shall not be installed over tracks or extend beyond the inside of the platform edge granite unless otherwise specified or approved.

F. Cameras mounted to suspended ceiling panels shall be installed flush with the ceiling panel and all wiring shall be concealed within the suspended ceiling.

G. Cameras mounted to elevator ceiling panels shall be installed flush with the ceiling panel and all wiring shall be concealed within the suspended ceiling

H. Enclosures shall be weather-proof, NEMA4X Stainless Steel enclosures with a padlock hasp.

I. Enclosures shall be mounted no more than 5’-6” above finished floor.

J. All cables shall be installed and tested in accordance with the most current WMATA Design and Wiring Standards.

2.04 FIELD QUALITY CONTROL

A. Design and Performance Testing: Perform tests and submit results in accordance with the General Provisions, certified test results for the CCTV system installed under this contract.

B. Acceptance Testing:

1. Furnish equipment required to perform tests.
2. Comply with WMATA approved system testing.
3. Perform approved tests to verify that the CCTV systems comply with requirements shown and specified.

2.05 ADJUSTING

A. **CONFIGURATION AND ADJUSTMENT**

1. Configure and document all parameters required for optimized camera operation.
2. All initial camera views shall be setup with a level widest angle view.
3. Adjust cameras and document as required to capture the view as shown on approved drawings.
4. Focus cameras using Rotakin focusing tool.
5. All camera views shall minimize the ceiling or sky to maximize the public space.

2.06 CLEANING

A. Cameras:

1. All cameras and domes shall be free of finger prints and smudges.

B. Waste Management:

1. All packaging, project waste and debris shall be removed after each shift and deposed of in contractor provided bins or dumpsters.

2.07 PROTECTION

A. Contractor is responsible for all devices until accepted by WMATA.

B. All communication enclosures shall be locked will padlocks once mounted on walls. No enclosures shall be unattended and unlocked once the switches are active.

2.08 DEMONSTRATION

A. Conduct walking tour of Project and briefly describe function, operation and maintenance of the system components.

B. Demonstrate operation and maintenance of the system to WMATA personnel two weeks prior to date of Substantial Completion.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with W MATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance and shutdown of each item of equipment at equipment location.

E. Prepare and insert additional data in operations and maintenance manuals as needed for additional data becomes apparent during instruction.

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP001 - SECTION 284400
REFRIGERANT DETECTION AND ALARM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

1.02 SUMMARY

A. This section specifies work pertaining to This Section includes refrigerant monitors, and notification appliances.

B. The following sections include related requirements and are performed by other trades

1. WIRE, CABLE AND BUSWAY: Section 16120
2. WIRE CONNECTION ACCESSORIES: Section 16125
3. RACEWAYS, BOXES AND CABINETS: Section 16130
4. WIRING AND CONTROL DEVICES: Section 16145

C. Definitions: All terms in this specification have the meaning as defined in the ASME code.

1. LCD: Liquid-crystal display.
2. LED: Light-emitting diode.
3. PIR: Photoacoustic infrared.

1.03 REFERENCES

A. Codes, Regulations, Reference Standards and Specifications.

1. ASHRAE 15

1.04 SUBMITTALS

Submit the following for approval in accordance with the Contract Documents and with the additional requirements as specified.

A. Product Data:

1. For each type of refrigerant monitor, include refrigerant sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.

B. Shop Drawings:

1. Air-Sampling Tubing: Size, routing, and termination including elevation above finished floor.

2. Wiring Diagrams: Power, signal, and control wiring.

C. INFORMATIONAL SUBMITTALS

1. Coordination Drawings: Include elevator machine room layout showing location of monitoring devices and air-sampling tubing with filter/inlet locations in relation to refrigerant equipment.

2. Product Certificates: For monitoring devices, signed by product manufacturer.

3. Field quality-control test reports.

D. CLOSEOUT SUBMITTALS

1. Operation and Maintenance Data: For refrigerant monitoring equipment to include in emergency, operation, and maintenance manuals.

E. MAINTENANCE MATERIAL SUBMITTALS

1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

a) One calibration kit including clean air calibration gas bottle for zero calibration and specific refrigerant calibration gas for span calibration, minimum 58-L capacity, pressure regulator, and tubing.

F. COORDINATION

1. Coordinate refrigerant detection and alarm system with refrigerant contained in refrigeration equipment for compatibility.

PART 2 – PRODUCTS

2.01 PIR REFRIGERANT MONITOR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. MSA: Chillgard Refrigerant Monitors.

2. Haloguard Monitors

3. Approved equal.

B. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and automatically activating ventilation system.

C. Standard: Monitoring system shall comply with ASHRAE 15.

D. Performance:

1. Refrigerant to Be Monitored R-410A.

2. Range: 0 to 1000 ppm.

3. Sensitivity:
   a) Accuracy: 0 to 50 ppm; plus or minus 1 ppm. 51 to 1000 ppm; plus or minus 10 percent of reading.
   b) Repeatability: Plus or minus 1 percent of full scale.
   c) Response: Maximum 10 seconds per sample.
   d) Detection Level Set Points:

      (1) Detection Level 1: 20 ppm.
      (2) Detection Level 2: 50 ppm.
      (3) Detection Level 3: 250 ppm.

E. Input/Output Features:

1. Maximum Power Input: 120-V ac, 60 Hz, 75 W.

2. Number of Air-Sampling Points: One.

3. Air-Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.

4. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.

5. Alarm Relays: Minimum 4 relays at a minimum of 5-A resistive load each.

6. Alarm Set Points: Displayed and adjustable through keypad on front of meter.

7. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.

8. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.

9. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.

10. Audible Output: Minimum 75 dB at 10 feet.

11. Visible Output: Strobe light.

12. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.

13. Serial Output: RS-232 or RS-485.

14. Enclosure: NEMA 250, Type 1, with locking quarter-turn latch and key.

F. MONITOR ALARM SEQUENCE

A. Detection Level 1: Notify HVAC control workstation of detection in the elevator machine room on a rise or fall of refrigerant concentration to this level. Increase ventilation system from low speed to high speed to allow occupancy by maintenance technicians to identify leaks. Cycle blue strobe lights.

B. Detection Level 2: Notify the HVAC control workstation of the detection in the elevator machine room on a rise or fall of refrigerant concentration to this level. Operate the ventilation system on high speed. Cycle amber strobe lights.

C. Detection Level 3: Notify the HVAC control workstation of the detection in the elevator machine room on a rise or fall of refrigerant concentration to this level. Sound alarm horns and cycle red strobe lights inside elevator machine room. Provide manual reset for this detection level.

D. Sensor Fault/Trouble: Notify HVAC control workstation of fault/trouble detection in monitor.

E. Please note: The inter connection of the refrigerant monitor and HVAC control workstation is not required under this scope of work but will be connected in the future under separate contract. The capability to notify (ability to send a signal) is required so that the owner may take advantage of this capability in the future.

2.02 NOTIFICATION APPLIANCES

A. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn.

B. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "REFRIGERANT DETECTION" printed in minimum 1/2-inch- high letters on the lens. Rated light output is 75 candela.

2.03 AIR-SAMPLING TUBING

A. Annealed-Temper Copper Tubing: ASTM B 88, Type L.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with ASHRAE 15.

B. Install air-sampling inlets, or diffusion type monitors in the elevator machine room that are accessible to personnel.

C. Floor mount diffusion-type monitor, sensor/transmitters, or air-sampling inlets on slotted channel frame 12 to 18 inches above the floor in a location near the refrigerant source or between the refrigerant source and the ventilation duct inlet.

D. Wall mount air-sampling multiple-point monitors with top of unit 60 inches above finished floor.

E. Run air-sampling tubing from monitor to air-sampling point, in size as required by monitor manufacturer. Install tubing with maximum unsupported length of 36 inches, for tubing exposed to view. Terminate air-sampling tubing at sampling point with filter recommended by monitor manufacturer.

F. Install air-sampling tubing with sufficient slack and flexible connections to allow for vibration of tubing and movement of equipment.

G. Purge air-sampling tubing with dry, oil-free compressed air before connecting to monitor.

H. Number-code or color-code air-sampling tubing for future identification and service of air-sampling multiple-point monitors.

I. Extend air-sampling tubing from exhaust part of multiple-point monitors to exhaust fan inlet.

J. Place warning signs inside and outside each door to the elevator machine room. Sample wording: "AUDIBLE AND VISUAL ALARM SOUNDING INDICATES REFRIGERANT DETECTION – WAIT 30 MINUTES BEFORE ENTERING."

K. Audible Alarm-Indicating Devices: Install at each entry door to elevator machine room, and position not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

L. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn at each entry door to elevator machine room, and position at least 6 inches below the ceiling.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.

2. Test and adjust controls and safeties.

3. Test Reports: Prepare a written report to record the following:
   a) Test procedures used.

b) Test results that comply with requirements.
c) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Repair or replace malfunctioning units and retest as specified above.

3.03 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant detection devices. Refer to requirements in Section 017900 "Demonstration and Training."

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP002 – 13905 SECTION
FIRE PROTECTION, SUPPRESSION AND ALARM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

1.02 SUMMARY

A. This section specifies work pertaining to the dry pipe sprinkler system.

B. The following sections include related requirements.

FIRE PROTECTION, SUPPRESSION AND ALARM: Section 13905.

1.03 REFERENCES

A. Codes, Regulations, Reference Standards and Specifications.

1. Same as in Section 13905.

1.04 QUALITY ASSURANCE

A. Same as in Section 13905.

1.05 SUBMITTALS

A. Product Data

1. Same as in Section 13905.

PART 2 – PRODUCTS

1.1 SYSTEM DESCRIPTIONS

A. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

1.2 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Specialty Valves Pressure Rating: 175-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Dry-Pipe Valves:
1. Standard: UL 260.
2. Design: Differential-pressure type.
3. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
4. Air-Pressure Maintenance Device:
   a. Standard: UL 260.
   b. Type: Automatic device to maintain minimum air pressure in piping.
   c. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig outlet pressure.

5. Air Compressor:
   a. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
   b. Motor Horsepower: Fractional.
   c. Power: 120-V ac, 60 Hz, single phase.

1.3 SPRINKLER

A. Use sprinkler types below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Dry recessed sprinklers.
3. Wall Mounting: Dry sidewall sprinklers.

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP003 – SECTION 14200
CONVEYING SYSTEMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

1.02 SUMMARY

A. This section specifies work pertaining to Division 14200 Conveying Systems and project specific items related to the existing Metro Station.

PART 2 – PRODUCTS

2.01 ELEVATOR MACHINE ROOM

A. The elevator machine room as shown in section 3.07 Exhibit 1 shall be as shown on the architectural drawings due to the site constraints.

B. Elevator Contractor shall follow the Architectural drawing in producing the elevator machine room drawing for approval, and subsequent installation.

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP004 – SECTION 16705
COMMUNICATIONS – EQUIPMENT & MATERIALS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

1.02 SUMMARY

A. This section specifies work pertaining to the equipment and materials.

B. The following sections include related requirements.

COMMUNICATIONS STANDARD SPECIFICATIONS – EQUIPMENT & MATERIAL: Section 16705.
COMMUNICATIONS – CALL FOR AID: Section 16728.
COMMUNICATIONS – ELECTRONIC ACCESS CONTROL SYSTEM: Section 16740.
COMMUNICATIONS – CLOSED-CIRCUIT TELEVISION SYSTEM: Section 16851.

1.03 REFERENCES

A. Codes, Regulations, Reference Standards and Specifications.

1. Same as in Section 16705.

1.04 QUALITY ASSURANCE

A. Same as in Section 16705.

1.05 SUBMITTALS

A. Product Data

1. Same as in Section 16705 & 16706.

PART 2 – PRODUCTS

2.1 COPPER CATEGORY 6 PATCH PANEL

A. The copper category 6 patch panel shall meet the following minimum requirements:

1. Make/Model: Ortronics OR-PHD66U24 or approved equivalent

2. Jack wiring: TIA/EIA 568 A/B

3. Dimensions (maximum):
   a. 1.75 × 19.00 × 1.25 in (44.25 × 482.60 × 31.75 mm)

4. Cable diameter range: 22-26 AWG

5. Number of ports: 24

6. Mounting: Rack mount

7. Compliance:
   a. ETL verified
   b. CUL verified
   c. FCC listed
   d. UL listed

2.2 COPPER CATEGORY 6 CABLE

A. The copper category 6 cable shall meet the following minimum requirements:

1. Make/Model: Superior Essex 66-240-2B or approved equivalent

2. Cable labeling: All cabling shall be labeled as shown on accepted shop drawings for type, location, and service.

3. Applications:
   a. 10Base-T through 1000Base-T Ethernet
   b. Power over Ethernet (PoE) – IEEE 802.3af
   c. PoE+ IEEE 802.3at Type 1 and 2

4. Insulation:
   a. CMR: Polyolefin
   b. CMP: FEP

5. Jacket:
   a. CMR: Flame retardant (FR) PVC
   b. CMP: FR, low smoke PVC

6. Characteristic Impedance: 100 +/- Ohms

7. Number of ports: 24

8. Performance compliance:

a. UL 444
b. CSA C22.2 No. 214-08
c. UL 1666
d. NFPA 262
e. ANSI/TIA-568-C.2
f. Article 800, NEC (NFPA 70)
g. RoHS-compliant

2.3 COPPER CATEGORY 6 CABLE CONNECTORS

A. The copper category 6 cable connectors shall meet the following minimum requirements:

1. Make/Model: Ortronics FTPUC65E or approved equivalent

2. Cable connector labeling: All cabling connectors shall be labeled as shown on accepted shop drawings for type, location, and service.

3. Applications:
   a. 10Base-T through 1000Base-T Ethernet
   b. Power over Ethernet (PoE) – IEEE 802.3af
   c. PoE+ IEEE 802.3at Type 1 and 2

4. Plug Type: RJ 45

5. Supported conductors:
   a. Solid conductors: 22-26 AWG
   b. Stranded conductors: 23-27 AWG

6. Supports up to 5 re-terminations

7. Performance rating: CAT6 & CAT5E

8. Performance compliance:
   a. UL 1863
   b. CUL listed
   c. RoHS-compliant

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP005 – 16851 SECTION
COMMUNICATIONS – CLOSED-CIRCUIT TELEVISION SYSTEM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

1.02 SUMMARY

A. This section specifies work pertaining to the closed-circuit television system.

B. The following sections include related requirements.

COMMUNICATIONS – CLOSED-CIRCUIT TELEVISION SYSTEM: Section 16851.

1.03 REFERENCES

A. Codes, Regulations, Reference Standards and Specifications.

1. Same as in Section 16851.

1.04 QUALITY ASSURANCE

A. Same as in Section 16706 & 16851.

1.05 SUBMITTALS

A. Product Data

1. Same as in Section 16851.

PART 2 – PRODUCTS

2.1 MEDIA CONVERTERS (STANDARD POE CAT6 TO COAX)

A. The media converters shall meet the following minimum requirements:

1. Make/Model: Veracity VLS-1P-BC & VLS-1P-CC (Both required)

2. Environmental Factors:
   a. Operating Temperatures:
      1) -40˚C to 70˚C (-40˚F to 158˚F)
   b. Operating and Storage Humidity:
      1) 0-85% RH (non-condensing)

3. Power Requirements:
   a. Power over Ethernet IEEE 802.3af

4. Dimensions (maximum):
   a. 4.75 × 2.25 × 1.25 in (115 × 55 × 30 mm)

5. Mounting:
   a. DIN Rail
   b. Wall mount

6. Interface:
   a. 1 (one) RJ45 connector (10/100 Mbps)
   b. 1 (one) BNC connector (75 Ohm)
   c. 1x power

7. Salient Characteristics:
   a. Display and Indicators:
      1) Power LED indicator; Network LED indicator
   b. Compliance:
      1) RoHS, FCC, CE, BS EN 50121-4

2.2 360° CAMERA

A. The 360° cameras shall meet the following minimum requirements:

1. Make/Model: Axis M3057-PVE

2. Environmental Factors:
   a. Indoor/Outdoor
   b. Operating Temperatures:
      1) -40˚C to 50˚C (-40˚F to 122˚F)
   c. Operating and Storage Humidity:
      1) 10-100% RH (condensing)

3. Power Requirements:
   a. Power over Ethernet IEEE 802.3af
   b. DC 12V +/- 10%
   c. Power Consumption: Maximum 12.95W

4. Mounting:
   a. Wall
   b. Ceiling

5. Interface:
   a. RJ45 connector 10 BASE-T/100BASE-TX PoE

6. Salient Characteristics:
   a. Image sensor: 6 MP 1/1.8” CMOS, progressive scan
   b. Lens: Fixed iris, fixed focus, 1.6 mm, F2.0
   c. Field of view: 180° Horizontal (360° Panoramic view when ceiling mounted)
   d. Minimum illumination:
      1) Color: 0.16 lux at 50 IRE F2.0
      2) B/W: 0.03 lux at 50 IRE F2.0
      3) 0 lux with IR illumination on

e. Video compression: H.264, MPEG4, MJPEG
f. Frame rate:
    1) 360° overview only, up to 2048x2048 without WDR: 50 FPS
    2) 360° overview and dewarped views, up to maximum resolution with WDR: 25 FPS
g. Video streaming: Multiple, individually configurable streams in H.264 and MJPEG
h. Illuminator:
    1) Type: IR LED
    2) Range: 33 ft.

2.3 POE SURGE PROTECTION MODULE

A. The PoE surge protection module shall meet the following minimum requirements:

1. Make/Model: Black Box SPD075A or approved equivalent

2. Port type: RJ-45 in and out, Category 6 Ethernet, all wire shall be protected

3. Clamping voltage: 60V

4. Response time: 5 nanoseconds

5. Shall be modular allowing each to be changed as needed in the event of failure

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP006 – SECTION 02465
HELICAL SCREW FOUNDATIONS

PART 1 – GENERAL

1.1 Purpose of Specification

The purpose of this specification is to detail the furnishing of all designs, materials, tools, equipment, labor and supervision, and installation techniques necessary to install HELICAL SCREW FOUNDATIONS (HSF), also known as helical piles, as detailed on the drawings, including connection details. This shall include provisions for load testing that may be part of the scope of work

1.2 Scope of Work

This work consists of furnishing all necessary, supervision, labor, tools, materials, and equipment to perform all work necessary to install the HELICAL SCREW FOUNDATIONS as per the specifications described herein, and as shown on the drawings. The Contractor shall install a helical screw foundation that will develop the load capacities as detailed on the drawings.

1.3 Qualifications of the Helical Screw Foundation Contractor

The HSF Contractor shall be experienced in performing design and construction of helical screw foundations and shall furnish all materials, labor, and supervision to perform the work. The Contractor shall be certified by the manufacturer and/or their authorized representatives in the proper methods of design and installation of helical screw foundations.

The HSF Contractor shall not sublet the whole or any part of the contract without the express written permission of the Owner.

1.4 Allowable Tolerances

1.4.1 Centerline of helical screw foundations shall not be more than 3 inches from indicated plan location.

1.4.2 Helical screw foundation plumbness shall be within 5° of design alignment.

1.4.3 Top elevation of helical screw foundation shall be within +1 inch to –2 inches of the design vertical elevation.

1.5 Quality Assurance

1.5.1 Helical screw foundations shall be installed by a contractor certified by the manufacturer and/or their authorized representatives.

1.5.2 The Contractor shall employ an adequate number of skilled workers who are experienced in the necessary crafts and who are familiar with the specified requirements and methods needed for proper performance of the work of this specification.

1.5.3 All HSFs shall be installed in the presence of a designated representative of the Owner unless said representative informs the Contractor otherwise. The designated representative shall have the right to access to any and all field installation records and test reports.

1.5.4 Screw foundation components as specified therein shall be manufactured by a facility whose quality systems comply with ISO (International Organization of Standards) 9001 requirements. Certificates of Registration denoting ISO Standards Number shall be presented upon request to the Owner or their representative.

1.6 Ground Conditions

The Geotechnical Report(s), including logs of soil borings as shown on the boring location plan, shall be considered to representative of the in-situ subsurface conditions likely to be encountered on the project site. As required for the design, additional subsurface investigations shall be performed and documented in a supplementary geotechnical report. These Geotechnical Report(s) shall be used as the basis for helical screw foundation design using generally accepted engineering judgement and methods.

2 REFERENCED CODES AND STANDARDS

Standards listed by reference, including revisions by issuing authority, form a part of this specification section to the extent indicated. In case of conflict, the particular requirements of this specification shall prevail. The latest publication as of the issue of this specification shall govern, unless indicated otherwise.

2.1 American Society for Testing and Materials (ASTM):

2.1.1 ASTM A29/A29M Steel Bars, Carbon and Alloy, Hot-Wrought and Cold Finished.
2.1.2 ASTM A36/A36M Structural Steel.
2.1.3 ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
2.1.4 ASTM A153 Zinc Coating (Hot Dip) on Iron and Steel Hardware.
2.1.5 ASTM A252 Welded and Seamless Steel Pipe Piles.
2.1.6 ASTM A775 Electrostatic Epoxy Coating
2.1.7 ASTM A193/A193M Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service.
2.1.8 ASTM A320/A320M Alloy-Steel Bolting Materials for Low Temperature Service.
2.1.9 ASTM A500 Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
2.1.10 ASTM A572 HSLA Columbium-Vanadium Steels of Structural Quality.
2.1.11 ASTM A618 Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing.
2.1.12 ASTM A656 Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability.
2.1.13 ASTM A1018 Steel, Sheet and Strip, Heavy Thickness Coils, Hot Rolled, Carbon, Structural, High-Strength Low-Alloy, Columbium or Vanadium, and High-Strength Low-Alloy with Improved Formability.
2.1.14 ASTM D1143 Method of Testing Piles Under Static Axial Compressive Load.
2.1.15 ASTM D3689 Method of Testing Individual Piles Under Static Axial Tensile Load.

2.2 American Welding Society (AWS):

2.2.1 AWS D1.1 Structural Welding Code – Steel.
2.2.2 AWS D1.2 Structural Welding Code – Reinforcing Steel.

2.3 American Society of Civil Engineers (ASCE):

2.3.1 ASCE 20-96 Standard Guidelines for the Design and Installation of Pile Foundations.

2.4 Deep Foundations Institute (DFI):

2.4.1 *Guide to Drafting a Specification for High Capacity Drilled and Grouted Micropiles for Structural Support*, 1st Edition, Copyright 2001 by the Deep Foundation Institute (DFI).

2.5 Post Tensioning Institute (PTI):

2.5.1 *Recommendations for Prestressed Rock and Soil Anchors*, Third Edition, Copyright 1996 By the Post-Tensioning Institute.

2.6 Society of Automotive Engineers (SAE):

2.6.1 SAE J429 Mechanical and Material Requirements for Externally Threaded Fasteners.

3 SUBMITTALS

3.1 Construction Submittals

3.1.1 The Contractor shall submit a detailed description of the construction procedures proposed for use to the Owner for review. This shall include a list of major equipment to be used.

3.1.2 The technical submittal shall include the following:

3.1.2.a Helical Screw Foundation number, location and pattern by assigned identification number
3.1.2.b HSF design load
3.1.2.c Type and size of central steel shaft
3.1.2.d Helix configuration (number and diameter of helix plates)
3.1.2.e Minimum effective installation torque
3.1.2.f HSF attachment to structure relative to grade beam, column pad, pile cap, etc.

3.1.3 The Contractor shall submit shop drawings for all HSF components including pile top attachment to the Owner for review and approval. This includes HSF lead and extension section identification (manufacturer's catalog numbers).

3.1.4 Work shall not begin until all the submittals have been received and approved by the Owner.

3.1A Design Requirements

The design of the HSF shall conform to Acceptance Criteria AC358, including the allowable axial load per Section 1810.3.3.1.9 of the 2012 IBC. The contractor shall submit all design calculations to the Owner for review and approval.

3.2 Installation Records

The Contractor shall provide the Owner copies of HSF installation records within 24 hours after each installation is completed. Formal copies shall be submitted on a weekly basis. These installation records shall include, but are not limited to, the following information.

3.2.1 Name of project and Contractor
3.2.2 Name of Contractor's supervisor during installation
3.2.3 Date and time of installation
3.2.4 Name and model of installation equipment
3.2.5 Type of torque indicator used
3.2.6 Location of HSF by assigned identification number
3.2.7 Actual HSF type and configuration – including lead section (number and size of helix plates), number and type of extension sections (manufacturer's SKU numbers)
3.2.8 HSF installation duration and observations
3.2.9 Total length of installed HSF

3.2.10 Cut-off elevation
3.2.11 Inclination of HSF
3.2.12 Installation torque at one-foot intervals for the final 10 feet
3.2.13 Comments pertaining to interruptions, obstructions, or other relevant information
3.2.14 Rated load capacities

4 PRODUCTS AND MATERIALS

4.1 Central Steel Shaft:

The central steel shaft, consisting of lead sections, helical extensions, and plain extensions, shall be Type SS or HS or a combination of the two (SS to HS Combo Pile) as manufactured by the A. B. Chance Company (Centralia, MO), or approved equal.

4.1.1 *SS5 1-1/2" Material*: Shall be hot rolled Round-Cornered-Square (RCS) solid steel bars meeting dimensional and workmanship requirements of ASTM A29. The bar shall be modified medium carbon steel grade (similar to AISI 1044) with improved strength due to fine grain size.

4.1.1.a Torsional strength rating = 5,500 ft-lb
4.1.1.b Minimum yield strength = 70 ksi

4.1.2 *SS150 1-1/2"; SS175 1-3/4; SS200 2"; SS225 2-1/4" Material*: Shall be hot rolled Round-Cornered-Square (RCS) solid steel bars meeting the dimensional and workmanship requirements of ASTM A29. The bar shall be High Strength Low Alloy (HSLA), low to medium carbon steel grade with improved strength due to fine grain size.

4.1.2.a Torsional strength rating: SS150 = 7,000 ft-lb; SS175 = 10,000 ft-lb; SS200 = 15,000 ft-lb; SS225 = 20,000 ft-lb
4.1.2.b Minimum yield strength = 90 ksi

4.1.3 *HS 3-1/2" OD Material*: Shall be structural steel tube or pipe, seamless or straight-seam welded, per ASTM A53, A252, ASTM A500, or ASTM A618. Wall thickness is 0.300" (schedule 80).

4.1.3.a Torsional strength rating = 11,000 ft-lb
4.1.3.b Minimum yield strength = 50 ksi

4.1.4 *Type RS2875 2-7/8" OD Material*: Structural steel tube or pipe, welded or seamless, in compliance with ASTM A500 or A513. Wall thickness is 0.165", 0.203" or 0.262".

4.1.4.a Torque strength rating: RS2875.165 = 4,500 ft-lb; RS2875.203 = 5,500 ft-lb; RS2875.262 = 7,500 ft-lb.
Minimum yield strength = 50 ksi

4.1.5 *SS to HS Combo Pile Material*: Shall be Type SS and HS material as described above with a welded adapter for the transition from SS to HS.

4.2 Helix Bearing Plate:

Shall be hot rolled carbon steel sheet, strip, or plate formed on matching metal dies to true helical shape and uniform pitch. Bearing plate material shall conform to the following ASTM specifications.

4.2.1 *SS5 Material*: Per ASTM A572, or A1018, or A656 with minimum yield strength of 50 ksi. Plate thickness is 3/8".
4.2.2 *SS150 and SS175 Material*: Per ASTM A656 or A1018 with minimum yield strength of 80 ksi. Plate thickness is 3/8".

4.2.3 *SS200 and SS225 Material*: Per ASTM A656 or A1018 with minimum yield strength of 80 ksi. Plate thickness is ½".
4.2.4 *HS Material*: Per ASTM A36, or A572, or A1018, or A656 depending on helix diameter, per the minimum yield strength requirements cited above. Plate thickness is 3/8".
4.2.5 *RS2875 Material*: Per ASTM A36, or A572, with minimum yield strength of 36 ksi. Plate thickness is 3/8" or ½".

4.3 Bolts:

The size and type of bolts used to connect the central steel shaft sections together shall conform to the following ASTM specifications.

4.3.1 *SS5 and SS150 1-1/2" Material*: 3/4" diameter bolt per ASTM A320 Grade L7.
4.3.2 *SS175 1-3/4" Material*: 7/8" diameter bolt per ASTM A193 Grade B7.
4.3.3 *SS200 2" Material*: 1-1/8" diameter bolt per ASTM A193 Grade B7.
4.3.4 *SS225 2-1/4" Material*: 1-1/4" diameter bolt per ASTM A193 Grade B7.
4.3.5 *HS 3-1/2" OD Material*: ¾" diameter bolts (3 per coupling) per SAE J429 Grade 5.
4.3.6
RS2875 2-7/8" OD Material: ¾" diameter bolts (2 or 4 per coupling) per SAE J429 Grade 5 or 8.

4.4 Couplings:

Shall be formed as integral part of the plain and helical extension material. For Type HS material, the couplings shall be hot forge expanded sockets.

4.5 Plates, Shapes, or Pier Caps:

Structural steel plates and shapes for HSF top attachments shall conform to ASTM A36 or ASTM A572 Grade 50.

4.6 Corrosion Protection

4.6.1 Galvanization: All A. B. Chance Type HS material shall be hot-dipped galvanized in accordance with ASTM A123 after fabrication.

5 EXECUTION

5.1 Site Conditions

5.1.1 Prior to commencing helical screw foundation installation, the Contractor shall inspect the work of all other trades and verify that all said work is completed to the point where HSFs may commence without restriction.

5.1.2 The Contractor shall verify that all HSFs may be installed in accordance with all pertinent codes and regulations regarding such items as underground obstructions, right-of-way limitations, utilities, etc.

5.1.3 In the event of a discrepancy, the Contractor shall notify the Owner. The Contractor shall not proceed with HSF installation in areas of discrepancies until said discrepancies have been resolved. All costs associated with unresolved discrepancies shall be the responsibility of the Owner.

5.2 Installation Equipment

5.2.1 Shall be rotary type, hydraulic power driven torque motor with clockwise and counter-clockwise rotation capabilities. The torque motor shall be capable of continuous adjustment to revolutions per minute (RPM's) during installation. Percussion drilling equipment shall not be permitted. The torque motor shall have torque capacity 15% greater than the torsional strength rating of the central steel shaft to be installed.

5.2.2 Equipment shall be capable of applying adequate down pressure (crowd) and torque simultaneously to suit project soil conditions and load requirements. The equipment shall be capable of continuous position adjustment to maintain proper HSF alignment.

5.3 Installation Tooling

5.3.1 Shall consist of a Kelly Bar Adapter (KBA) and Type SS or HS drive tool as manufactured by A. B. Chance Company, or approved equal, and used in accordance with the manufacturers written installation instructions.

5.3.2 A torque indicator shall be used during HSF installation. The torque indicator can be an integral part of the installation equipment or externally mounted in-line with the installation tooling.

5.3.2.a Shall be capable of providing continuous measurement of applied torque throughout the installation.

5.3.2.b Shall be capable of torque measurements in increments of at most 500 ft-lb

5.3.2.c Shall be calibrated prior to pre-production testing or start of work. Torque indicators which are an integral part of the installation equipment, shall be calibrated on-site. Indicators that measure torque as a function of hydraulic pressure shall be calibrated at normal operating temperatures. Prior to installation, the contractor shall submit testing and calibration certificates for torque indicator equipment to be used.

5.3.2.d Shall be re-calibrated, if in the opinion of the Owner and/or Contractor reasonable doubt exists as to the accuracy of the torque measurements.

5.4 Installation Procedures

5.4.1 *Central Steel Shaft: (Lead and Extension Sections)*

5.4.1.a The HSF installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project.

5.4.1.b The lead section shall be positioned at the location as shown on the working drawings. Battered HSFs can be positioned perpendicular to the ground to assist in initial advancement into the soil before the required batter angle shall be established. The HSF sections shall be engaged and advanced into the soil in a smooth, continuous manner at a rate of rotation of 5 to 20 RPM's. Extension sections shall be provided to obtain the required minimum overall length and installation torque as shown on the working drawings. Connect sections together using coupling bolt(s) and nut torqued to 40 ft-lb.

5.4.1.c Sufficient down pressure shall be applied to uniformly advance the HSF sections approximately 3 inches per revolution. The rate of rotation and magnitude of down pressure shall be adjusted for different soil conditions and depths.

5.5 Termination Criteria

5.5.1 The torque as measured during the installation shall not exceed the torsional strength rating of the central steel shaft.

5.5.2 The minimum installation torque, minimum overall length criteria, or suitable bearing (helix not advancing with proper downpressure) as shown on the technical submittal shall be satisfied prior to terminating the helical screw foundation installation.

5.5.3 If the torsional strength rating of the central steel shaft and/or installation equipment has been reached prior to achieving the minimum overall length required, the Contractor shall have the following options:

5.5.3.a Terminate the installation at the depth obtained subject to the review and acceptance of the Owner, or:

5.5.3.b Remove the existing HSF and install a new one with fewer and/or smaller diameter helix plates. The new helix configuration shall be subject to review and acceptance of the Owner. If re-installing in the same location, the top-most helix of the new HSF shall be terminated at least (3) three feet beyond the terminating depth of the original HSF.

5.5.4 If the minimum installation torque as shown on the working drawings is not achieved at the minimum overall length, and there is no maximum length constraint, the Contractor shall have the following options:

5.5.4.a Install the HSF deeper using additional extension sections, or:

5.5.4.b Remove the existing HSF and install a new one with additional and/or larger diameter helix plates. The new helix configuration shall be subject to review and acceptance of the Owner. If re-installing in the same location, the top-most helix of the new HSF shall be terminated at least (3) three feet beyond the terminating depth of the original HSF.

5.5.4.c De-rate the load capacity of the HSF and install additional helical screw foundation(s). The de-rated capacity and additional helical screw foundation location shall be subject to the review and acceptance of the Owner.

5.5.5 If the HSF is refused or deflected by a subsurface obstruction, the installation shall be terminated and the pile removed. The obstruction shall be removed, if feasible, and the HSF re-installed. If the obstruction can't be removed, the HSF shall be installed at an adjacent location, subject to review and acceptance of the Owner.

5.5.6 If the torsional strength rating of the central steel shaft and/or installation equipment has been reached prior to proper positioning of the last plain extension section relative to the final elevation, the Contractor may remove the last plain extension and replace it with a shorter length extension. If it is not feasible to remove the last plain extension, the Contractor may cut said extension shaft to the correct elevation. The Contractor shall not reverse (back-out) the helical screw foundation to facilitate extension removal.

5.5.7 The average torque for the last three feet of penetration shall be used as the basis of comparison with the minimum installation torque as shown on the working drawings. The average torque shall be defined as the average of the last three readings recorded at one-foot intervals.

6 HELICAL SCREW FOUNDATION LOAD TESTS

6.1 Use the ASTM D1143A Section 8.1.2 "Quick Load"

6.2 Load Test Equipment

6.2.1 The load test equipment shall be capable of increasing or decreasing the applied load incrementally. The incremental control shall allow for small adjustments, which may be necessary to maintain the applied load for a sustained, hold period.

6.2.2 The reaction system shall be designed so as to have sufficient strength and capacity to distribute the test loads to the ground. It should also be designed to minimize its movement under load and to prevent applying an eccentric load to the pile head. Test loads are normally higher than the design loads on the structure. The direction of the applied load shall be collinear with the HSF at all times.

6.2.3 Dial gauge(s) shall be used to measure HSF movement. The dial gauge shall have an accuracy of at least +/-0.001-in. and a minimum travel sufficient to measure all HSF movements without requiring resetting the gauge. The dial gauge shall be positioned so its stem is parallel with the axis of the HSF. The stem may rest on a smooth plate located at the pile head. Said plate shall be positioned perpendicular to the axis of the HSF. The dial gauge shall be supported by a reference apparatus to provide an independent fixed reference point. Said reference apparatus shall be independent of the reaction system and shall not be affected by any movement of the reaction system.

6.2.4 The load test equipment shall be re-calibrated, if in the opinion of the Owner and/or Contractor reasonable doubt exists as to the accuracy of the load or deflection measurements.

6.3 Testing Program

6.3.1 Prior to testing, the contractor shall submit testing and calibration certificates for the hydraulic jacks to be used. The hydraulic jack shall be positioned at the beginning of the test such that the unloading and repositioning of the jack during the test shall not be required. The jack shall also be positioned co-axial with respect to the pile-head so as to minimize eccentric loading. The hydraulic jack shall be capable of applying a load not less than two times the proposed design load (DL). The pressure gauge shall be graduated in 100 psi increments or less. The stroke of the jack shall not be less than the theoretical elastic shortening of the total HSF length at the maximum test load.

6.3.2 An alignment load (AL) shall be applied to the HSF prior to setting the deflection measuring equipment to zero or a reference position. The AL shall be no more than 10% of the design load (i.e., 0.1 DL). After AL is applied, the test set-up shall be inspected carefully to ensure it is safe to proceed.

6.3.3 Axial compression or tension load tests shall be conducted by loading the HSF in step-wise fashion as shown in Table-3 to the extent practical. Pile-head deflection shall be recorded at the beginning of each step and after the end of the hold time. The beginning of the hold time shall be defined as the moment when the load equipment achieves the required load step.

6.3.4 Test loads shall be applied until continuous jacking is required to maintain the load step or until the test load increment equals 200% of the design load (DL) (i.e., 2.0 DL), whichever occurs first. The observation period for this last load increment shall be 10 minutes. Displacement readings shall be recorded at 1, 2, 3, 4, 5 and 10 minutes (load increment maxima only).

6.3.5 The applied test load shall be per ASTM D1143 Procedure a, Quick Test.

6.4 Acceptance Criteria for HSF Verification Load Tests

Both of the following criteria must be met for approval:

1. The HSF shall sustain the compression and tension design capacities (1.0 DL) with total vertical movement of the pile-head, as measured relative to the top of the HSF prior to the start of testing, not to exceed the maximum allowable as determined by the design engineer.
2. Failure does not occur at the 2.0 DL maximum compression and tension test loads. The failure load shall be defined by one of the following definitions – whichever results in the lesser load:

The Contractor shall provide the Owner copies of field test reports confirming HSF configuration and construction details within 24 hours after completion of the load tests. Formal copies shall be submitted as per Section 3.3. This written documentation will either confirm the load capacity as required on the working drawings or propose changes based upon the results of the pre-production tests.

When a HSF fails to meet the acceptance criteria, modifications shall be made to the design, the construction procedures, or both. These modifications include, but are not limited to, de-rating the HSF load capacity, modifying the installation methods and equipment, increasing the minimum effective installation torque, changing the helix configuration, or changing the HSF material (i.e., central steel shaft). Modifications that require changes to the structure shall have prior review and acceptance of the Owner. The cause for any modifications of design or construction procedures shall be decided in order to determine any additional cost implications.

In addition to the above, the HSF shall also meet WMATA pile testing requirements for static pile load tests per WMATA Specification Section 02460 3.02.B.2.d. (See SP007)

END OF SPECIFICATION

APPENDIX

TABLE-1

MECHANICAL STRENGTH RATINGS – HELICAL SCREW FOUNDATIONS

RATING TYPE	**CENTRAL STEEL SHAFT FAMILY**					
	SS5 1-1/2" RCS	**SS150 1-1/2" RCS**	**SS175 1-3/4" RCS**	**SS200 2" RCS**	**SS225 2-1/4" RCS**	**HS 3-1/2" O.D Pipe**
Torsional Strength Rating (ft-lb)	5,500	7,000	10,000	15,000	20,000	11,000
Ultimate Capacity Per Helix (kip) (Tension/Compression)	*40	*40	*50	60	60	50
Allowable Capacity Per Helix w/ 2.0 Safety Factor (kip) (Tension/Compression)	20	20	25	30	30	25
Ultimate Tension Capacity for Axially Loaded Pile (kip)	70	70	100	150	200	100

*** For 14" Dia. Helix Plates, Reduce the Ultimate Capacity by 20%**

NOTE: Actual installed capacities are dependent on existing soil conditions.

TABLE-1B

MECHANICAL STRENGTH RATINGS – Type RS HELICAL PILES

RATING TYPE	**CENTRAL STEEL SHAFT PRODUCT FAMILY**				
	RS2875.165 2-7/8" OD Pipe Shaft	**RS2875.203 2-7/8" OD Pipe Shaft**	**RS2875.262 2-7/8" OD Pipe Shaft**	**RS3500.300 2-7/8" OD Pipe Shaft**	**RS4500.337 4-1/2" OD Pipe Shaft**
Torque Strength Rating (ft-lb)	4,500	5,500	7,500	13,000	23,000
Ultimate Strength Per Helix (kip) (Tension/Compression)	*40	*40	*40	50	60
Uplift/Compression Capacity Limit[1] (kip)	36	44	60	91	138
Ultimate Tension Strength[2] (kip)	50	60	100	120	140

*** For 14" Dia. 3/8" Thick Helix Plates, Reduce the Ultimate Capacity by 20%**

1 - Based on torque rating – Uplift/Compression Capacity Limit = Torque Rating x Kt

"Default" Kt for Type RS2875 Series = 8, for Type RS3500.300 = 7, for Type RS4500.337 = 6

SP007 - SECTION 02460

PILES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing and installing bearing piles, performance of Static Pile Load Tests ~~and Dynamic Pile Testing.~~
   1. Sequence of Work:
      a. Conduct initial wave equation analysis, prepare Indicator Pile Order List and submit information to Engineer for review.
      b. Piles shall not be driven until embankments or excavations shown have been completed to the specified grade.
      ~~c. Obtain and drive the indicator piles where shown on the drawings. During initial driving perform Dynamic Pile Testing and the refined wave equation analysis on each indicator pile to confirm the length, and control blow count. Determine pile driving criteria on the basis of the pile driving analysis (PDA) during the initial driving and the static load test. Incorporate results into driving of subsequent indicator piles.~~
      d. Perform Static Pile Load Tests per Article 3.02.B.2 on indicator piles designated by the Engineer after all indicator piles have been installed. ~~After Static Load Test is complete immediately restrike all indicator piles with Dynamic Testing Apparatus installed and functioning.~~
      e. Analyze Static Pile Load Tests and evaluate data collected from Dynamic Pile Testing and refined wave equation analyses to determine pile driving criteria as indicated in item c.. Develop and submit the proposed "Order List" for production piles to the Engineer for approval.
      f. Order and procure production piles based on the approved "Order List".
      ~~g. Drive each production pile to twice the pile design load and "production maximum tip elevation", and report all data as specified to evaluate the adequacy of the foundation system.~~

B. Definitions:
   1. Pile Group: All piles to support a foundation element or column within a specified area, or all piles to support a linear unit of retaining wall. Pile groups are shown on the Contract Drawings.
   2. Production Piles: All piles ~~that are driven~~ after the installation of required test piles in accordance with the contract documents and which upon approval by the Engineer, become part of the permanent structure.
   3. Indicator Pile: Indicator piles are shown on the Contract Drawings. ~~These piles shall be tested with the Dynamic Testing Apparatus.~~ Static load tests shall be conducted on the indicator piles shown on the Contract Drawings or as directed by the Engineer. The Engineer may direct that additional indicator piles be driven and that dynamic or static testing be conducted on them to verify the load capacity.
   4. Reaction Piles: Piles driven by the Contractor to provide reaction for Static Pile Load Tests.

5. Predicted Maximum Tip Elevation: The elevation below which indicator pile tips must penetrate by at least one foot.
6. Production Maximum Tip Elevation: The elevation below which production pile tips must penetrate by at least one foot, based on the indicator pile test program.
7. Pile Design Load: The load each pile is designed to carry.
8. Ultimate Bearing Capacity: The maximum bearing capacity that the pile can sustain without rapid progressive settlement of the pile under constant load.

C. Pile Type:
1. ~~Prestressed precast concrete piles, driven.~~

D. Related Information:
1. Grading, Excavating, and Backfilling: Section 02320.
2. Support of Excavation: Section 02260.
3. Concrete Formwork: Section 03100.
4. Concrete Reinforcement: Section 03200.
5. Cast-in-Place Structural Concrete: Section 03300.
6. ~~Structural Precast Concrete: Section 03400.~~
7. ~~Prestressed Concrete: Section 03415.~~

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Codes and regulations of the jurisdictional authorities.
2. ASTM Standards:
a. D1143 - Test Method for Piles Under Static Axial Compressive Load.
b. ~~D4945 - Test Method for High Strain Dynamic Testing of Piles.~~

1.03 SUBMITTALS:

A. Submit the following for the Engineer's approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
a. For Static Pile Load Tests, provide drawings that show load test apparatus setup including the method of applying the load. Drawings must show devices to be used to measure pile top movement.
b. ~~For Dynamic Pile Testing, provide manufacturer's or vendor's data on transducers, computer, wiring, and schematic drawings for testing specified piles.~~
c. For Static Pile Load Test ~~and Dynamic Pile Testing programs,~~ provide detailed sequence of testing, evaluation of results and planned reports.
d. ~~Pile splicing is not desired and shall be avoided. In the event that concrete piles are driven below the elevation of bottom of cap, build-ups, precast or cast-in-place splicing may be used when approved by the Engineer. The pile submittal shall include splice details, build-up details and any other details necessary to satisfy the requirements of these specifications.~~

e. The pile submittal shall show ~~prestressing methods, tendon arrangement,~~ working stresses, and methods for pick-up and handling of piles.

f. Submit certification of accuracy for all gauges and test equipment.

2. Documentation:

~~a. Driving Equipment/Accessories List:~~

~~1) Submit details of proposed driving equipment to include cranes, leads, hammer, compressors, powerpacks, driving caps, hammer cushions and pile cushions. Data on hammer shall include as a minimum the manufacturer's model number, estimate of efficiency, energy ratings and ram details, including operation certification performed within the last 90 days.~~

~~2) Submit details of accessory equipment to be used including service cranes, hoses, throttles, and pile handling rigging.~~

~~b. Submit procedures and details for installation of reinforcement and prestressing.~~

~~c. Submit materials certifications and concrete mix designs for all concrete products to be used during the pile installation.~~

d. Indicator Pile Order List:

1) Submit a list of piles to be installed as part of the indicator pile test program. List shall show type, size, number, location, indicator pile order length, predicted maximum tip elevation, ~~allowable driving stress related to hammer blows, and blow count needed to attain twice the pile design load.~~ If locations for indicator piles differ from those shown on the drawings, provide reasons for change. The proposed revised location will be reviewed and, if appropriate, approved by the Engineer.

2) Submit list prior to ordering indicator piles.

e. Test Documentation and Reports:

~~1) The Contractor shall retain an experienced Engineer employed by a Dynamic Testing Consultant. The Dynamic Testing Consultant's Engineer shall be an integral part of the Contractor's Quality Control Program. Submit the qualifications of the Dynamic Testing Consultant's Registered Maryland Professional Engineer responsible for monitoring Static and Dynamic Pile Testing. The Dynamic Testing Consultant's Engineer shall have a minimum of five (5) years experience in similar work, of which two (2) years shall be field experience with the monitoring of pile driving operations. The Dynamic Testing Consultant shall provide the following:~~

~~a) Results of all Wave Equation Analyses using the GRLWEAP program, Dynamic tests, Static tests and the Case Pile Wave Analysis Program (CAPWAP). The GRLWEAP and CAPWAP program is a product of Globle Rausche Likins and Associates, Inc., 4535 Renaissance Parkway, Cleveland, OH 44128. Telephone (216)831-6131.~~

2) Sample pile driving record/report and sample sketch proposed to show any necessary deviations from planned locations.

3) An annotated sample of the dynamic testing apparatus output. Output shall include recorded input, reduced data and analysis.

4) After completion of each Static and/or Dynamic Pile Test, submit a test report for review and approval by the Engineer. The test report shall include reporting information specified in ASTM D1143 and D4945, results of the refined wave equation analyses, and recommendations for the Production Pile Order List.

5) Prepare a summary report of all the wave equation analyses, CAPWAP, and results of the dynamic and static pile tests. The report shall include test details, hammer and driving system details, soil conditions, instrumentation, test sequence and observations, discussions of test results (including hammer performance, driving stresses, pile integrity and pile capacity), and conclusions and recommendations for the Production Pile Order List.

f. Production Pile Order List:

1) After review and approval of the results of the Static Pile Load Test and Dynamic Pile Testing, submit an "Order List" of production piles proposed to be installed in each pile group. The list shall show type, size, number, location, sequence of installation, length, production maximum tip elevation , allowable driving stress related to hammer blows and blow count needed based on end of initial driving results to attain twice the pile design load for all piles in each pile group.

g. Pile Driving Record:

1) Maintain a record throughout the indicator pile test program and production pile driving operations and submit to the Engineer upon completion of each pile group. The record shall show the applicable established driving criteria developed by the Static Load Test, as modified by Dynamic Testing, for each pile. As a minimum include the following information:

a) Sequence in which piles were driven.

b) Equipment: type, model, serial number.

c) Required blow count per approved driving criteria, allowable driving stress related to hammer blows, production maximum tip elevation and final pile tip elevation.

d) Blow count for each foot of driven length.

e) For all piles, the number of blows per inch of penetration for last 12 inches.

f) Unusual conditions encountered during driving of each pile.

g) Immediately after final pile driving, record top elevation of pile to nearest 0.01 inch. Provide as-built pile information after all piles in a pile group have been driven.

1.04 PRODUCT DELIVERY AND HANDLING:

A. Lifting loops shall be used as provided by the precaster. Lifting loops shall not be tied in any way to the pile reinforcement. Loops may remain in place during driving. When handling and delivering precast piles, avoid bending and breaking or chipping of piles.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Precast concrete piles:
1. Prestressed precast concrete piles in accordance with Sections 03100, 03200, 03300, 03400, and 03415 of these specifications as applicable, shaped as shown.

B. Miscellaneous Driving Accessories: Including driving heads, collars, bands, shoes, and other driving devices in accordance with pile manufacturer's recommendations.

C. Lean concrete: Section 02260.

PART 3 - EXECUTION

3.01 DRIVING EQUIPMENT:

A. The Engineer will review submitted data on driving equipment, accessories and methods for adequacy in conditions expected.

B. Adequacy of equipment and accessories remains the responsibility of the Contractor.

C. Should the equipment used by the Contractor prove inadequate to drive scheduled types of piles at the locations shown, or should progress schedule not be maintained, the Engineer may require replacement of equipment or different expendable accessories or additional equipment.

D. If the hammer, driving block, cushion or any other part of the driving system is changed for any reason, the system must be calibrated by conducting Dynamic Pile Testing to prove the new system is equal to the original system. This work shall be made at no additional time to the Contract and at no cost to the Authority.

3.02 INDICATOR PILE TEST PROGRAM:

A. Installation:
1. No later than twenty-one (21) days prior to driving indicator piles, conduct initial wave equation analysis that represents the subsurface conditions on this project, the pile properties and driving equipment provided. This analysis shall be submitted along with the required pile and driving equipment data to the Engineer.
2. Provide and install indicator piles where shown, to determine lengths of production piles to be furnished to achieve twice the pile design load in the scheduled pile groups. If twice the design load is not attained when the top of the pile is one-foot above planned cut off, discontinue driving for a period of 24 hours or as directed by the Engineer. After the specified period, restrike pile in accordance with Article 3.02.B.1.b. If twice the design load is not attained after restrike, splice the pile, if necessary, and drive it until the specified bearing value is obtained.

3. Locate piles at contract pile locations so they can become part of the completed structure provided they are approved as conforming to requirements specified for production piles. Install indicator piles to achieve pile tips below the predicted maximum tip elevation, in the presence of the Engineer. Assist the Engineer in verifying measurements ~~and driving characteristics~~ as necessary to evaluate the adequacy of the foundation system.
4. The indicator piles scheduled for Static Pile Load Tests are shown on the Contract Drawings. The Engineer may designate alternate or additional indicator piles that exhibit the weakest bearing capacity for Static Pile Load Tests.
5. ~~Piles which are subjected to Static Pile Load Tests which do not pass the acceptance requirements shall be restruck, per 3.02. B.1.b with Dynamic Testing Apparatus installed and functioning, within 48 hours after completion of the Static Pile Load Test to reestablish the minimum required pile length and blow counts.~~
6. Additional piles may be ~~driven,~~ at the Contractor's option, in the area of the Static Load Test Piles to be used as reaction piles. All piles driven as indicator piles or reaction piles for load tests in accordance with the plans and specifications and meeting specified requirements for production piles can, upon approval, be cut off and become a part of the permanent structure.
7. Install all indicator piles that are intended to become part of the permanent structure with the same type and model of equipment and methods to be used to install production piles. Perform work in the presence of the Engineer.
8. Remove piles which are not incorporated into the completed structure or which do
not satisfy test requirements. Alternatively, if rejected piles are not removed then cut off at least three (3) feet below finished grade and backfill resulting hole with lean concrete.

B. Pile Testing:

~~1. Dynamic Pile Testing:~~

~~a. Perform Dynamic Pile Testing in accordance with ASTM D4945.~~

~~b. Install indicator piles where shown with the Dynamic Testing Apparatus installed and functioning to measure performance of the driving system and the bearing capacity. Begin dynamic testing during initial driving when the pile tip achieves the predicted maximum tip elevation. Drive indicator piles to a bearing capacity of at least twice the pile design load based on initial driving. Restrike all indicator piles, with Dynamic Testing Apparatus installed and functioning to verify results from initial driving of these piles. Restrike indicator piles with the hammer at normal operating temperature for a maximum penetration of twelve inches, a maximum of 60 hammer blows, or to less than the driving stress limits established by Article 3.03.B, whichever occurs first. Pile driving shall resume as if it was the initial strike conditions per Article 1.01.A.1.c to obtain the correct pile driving criteria~~

~~c. Perform CAPWAP analyses using the Dynamic Pile Testing data from the end of initial driving and the beginning of restrike of all indicator piles.~~

~~d. Perform refined wave equation analyses using the dynamic test results of each indicator pile. Incorporate the results of the refined wave equation analyses in driving of subsequent indicator piles. Refined wave equation analyses shall be based upon the variations in the~~

~~subsurface conditions and/or drive system performance measured by the dynamic testing apparatus.~~

2. Static Pile Load Tests:
   a. Static Pile Load Test equipment and testing procedures shall be in accordance with ASTM D1143, Quick Load Test Method, except as modified herein.
   b. Provide test equipment with capacity greater than ~~three~~ two times the pile design load and having means of determining applied load to within five (5) percent of test load. Provide test equipment capable of measuring total settlement at the top of the pile to nearest 0.001 inch.
   c. Perform Static Pile Load Tests. Commence loading the pile no sooner than 72 hours after installation of the pile. The maximum test load shall be equal to ~~three~~ two times the pile design load or the ultimate bearing capacity, whichever occurs first.
   d. The ultimate bearing capacity under axial comprehensive load is that load which produces a settlement of the pile head equal to:
      $S_u=S+(0.15+0.008D)$
      Where:
      S_u= Settlement at ultimate bearing capacity in inches
      S = Elastic deformation of total unsupported pile length in inches
      D = Pile diameter or width in inches
   e. The safe bearing capacity is defined as 50 percent of the maximum test load. Static load test results will be acceptable when the safe bearing capacity equals or exceeds the design bearing capacity.
   ~~f. Restrike piles for monitoring with Dynamic Testing Apparatus in accordance with Articles 3.02.A.5 and 3.02.B.1.~~

3.03 PRODUCTION PILE DRIVING:

A. Bearing Value, Length and Penetration:
   1. Provide production piles of length necessary to attain production maximum tip elevation, twice the pile design load, and to extend into cap or footing block as shown.
   2. Determine lengths of production piles by analysis of data obtained from Static Pile Load Tests, ~~Dynamic Pile Testing and refined wave equation analyses.~~
   3. Any pile that does not reach twice the pile design load by approved blow count or attain the minimum penetration will be rejected. ~~Rejected piles will be restruck after 48 hours in accordance with Article 3.02.B.1 and ,if necessary tested using Dynamic Pile Testing equipment as directed by the Engineer to prove attained capacity at no additional cost to the Authority.~~
   4. The Contractor may install additional test piles, make borings or make such other investigations as he may desire at no additional time to the Contract and no cost to the Authority.

~~B. Pile Driving Stresses:~~
   ~~1. Indicator and production piles shall not be driven above the hammer energy and blow count shown by the wave equation analyses to produce stresses~~

above the point of impending damage. For concrete piles limit the tensile (TS) and compressive (CS) driving stresses to:

$$TS = 3\sqrt{f_c'} + EPV$$

$$CS = 0.85 f_c' - EP$$

Where:

f_c' = The 28-day design compressive strength of the concrete

EPV = The effective prestress value

2. Cut off grade: At the Contractor's option, production piles reaching design bearing capacity and production maximum tip elevation with tops above the cut off grade may be driven to the cut off grade providing the required bearing capacity is maintained, allowable driving stresses within the pile have not been exceeded and no damage to the pile occurs. Piles damaged or suspected of damage due to driving to achieve a cut off grade shall be pulled and/or replaced at the Contractor's expense.

C. General Requirements:

1. Drive piles only after completion of required excavation or construction of indicated embankments.
2. Stage driving within supported excavation areas so as not to damage internal bracing.
3. For production piles in permanent embankments, pre-drill through fill or embankment to natural ground or bottom of embankment.
4. Drive each pile in a continuous operation until required penetration and twice the pile design load have been attained. If driving is stopped before required blow count and penetration have been reached, drive the pile one foot upon resumption of driving before resuming blow count for bearing value determination.
5. Redrive each pile which is lifted 1/4 inch or more by ground heave during driving of adjacent piles to at least the original tip elevation or as directed.
6. Remove loose and displaced material forced up around piles during driving.
7. In Terrace deposits and directly above the Monmouth Formation, cobbles, boulders and cemented sand/silt deposits were found. Penetrate into and through these deposits as necessary to attain twice the pile design load and required maximum tip elevation.
8. Achieve pile penetration through miscellaneous fill, rubble concrete, tires, hardpan, cemented sands/silts, and any other obstruction, natural or man-made, by means of pre-drilling or other approved excavation methods.
9. Hold pile tops in position with steel driving block or anvil.
10. Do not drive piles with free swinging hammer.
11. Pull and replace piles which are not within specified tolerances or, if approved, redesign pile cap as specified. Costs associated with the redesign and construction of modified pile caps will be borne by the Contractor and no additional time to the Contract will be allowed.

D. Pre-drilled Holes:

1. Where shown on the Contract Drawings, drill holes to diameter of greatest cross section dimension of the pile to be installed in accordance with the notes and schedules on the drawings and with Section 2.04.
2. Set pile in pre-drilled hole and drive to predicted or production maximum tip elevation and twice the pile design load, but in all cases to a minimum depth of five (5) feet below bottom of pre-drilled hole.
3. Fill voids between pre-drilled hole and pile with lean concrete immediately upon completion of the driving sequence, as approved.
4. Dispose of material resulting from drilling holes in accordance with the requirements of Section 204.
5. Fill rejected pre-drilled holes with lean concrete and redrill at approved location.

E. Concrete Piles:

1. Cut off piles at such elevation that they will extend into cap or footing as shown. Saw cut piles with equipment capable of providing a flat smooth surface without spalling or damaging pile below cutoff. Replace or repair piles that are damaged when cut off.
2. Where reinforcing steel dowels are shown, dowels may be anchored in cast or drilled holes in concrete pile. If holes are drilled, drill by methods that will not damage concrete, reinforcing steel or prestressing steel. Drill minimum diameter consistent with placing approved epoxy adhesive and dowel. Leave holes free of dust, moisture or other deleterious material. Place sufficient epoxy in holes before inserting dowels leaving no voids afterwards. Leave dowels undisturbed until epoxy has developed 100 percent of its strength capacity.

3.04 FIELD QUALITY CONTROL:

A. Concrete Pile Allowable Tolerances:

1. Ensure straightness and cross-sectional dimensions of precast piles so that a line stretched from butt to tip on any face is not more than one inch from face of pile at any point.
2. Install piles within the following tolerances:
   a. Axis of pile within six inches of design location at cutoff elevation.
   b. Axis of pile not out of plumb or batter by more than one percent of its driven length.
   c. No encroachment of piles upon neat lines of Authority structures.

PART 4 - MEASUREMENT AND PAYMENT

4.01 BASIS:

A. Compensation for work specified in this section will be made in the following manner:

1. Furnishing and installing piles: Linear foot in place in the completed work measured from the tip of the pile to the plane of the cut off (top of pile). This price shall include ~~conducting and reporting the initial wave equation analysis,~~ furnishing piles; ~~driving piles;~~ splices; concreting; achieving specified load and tip elevations.
2. Static Pile Load Test: This work will be measured and paid for at the Contract unit price per each static pile load test performed. The payment will be full compensation for furnishing and setup of test equipment, providing reaction piles, conducting test, reporting and incidentals necessary to complete the work. If load test is terminated by the Engineer because of insufficient bearing capacity, test will be measured for payment. If the test is terminated because of malfunction of Contractor's equipment or other reasons that are the fault of the Contractor, the test will not be measured for payment.
3. ~~Dynamic Pile Testing: This work will be measured and paid for at the Contract unit price per dynamic test performed. The payment will be full compensation for furnishing and setup of dynamic testing equipment and conducting test during initial and restrike driving of each indicator pile, performing CAPWAP analyses, performing the refined Wave Equation Analysis, reporting and incidentals necessary to complete the work. Incomplete tests and terminations treated in accordance with Article 4.A.2.~~
4. ~~Pile restrike: This work will be measured and paid for at the Contract unit price, per each restrike performed. The payment will be full compensation for furnishing and setup of pile driving equipment required for restriking piles with dynamic equipment installed and functioning in accordance with Article 3.2. If test is terminated by Engineer because of insufficient bearing capacity pile restrike will be measured for payment. If the test is terminated because of malfunction of Contractor's equipment or other reasons that are the fault of the Contractor, pile restrike will not be measured for payment.~~
5. ~~Pre-drilled holes shown and specified in Article 3.3 will be paid for at the Contract unit price per linear foot measured from the plane of the cut off (top of pile) to the level of the pre-drilled elevation specified. This price shall include providing the equipment, material and labor necessary to drill holes to the scheduled elevation, disposal of materials, placing lean concrete and incidentals necessary to complete the work.~~

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPECIAL PROVISION FOR

SP008 – SECTION 074213.19
INSULATED METAL WALL PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Foamed-insulation-core metal wall panels. Uninsulated single skin concealed fastener wall panel system.

1.3 RELATED REQUIREMENTS

A. Division 05 Section “Cold Formed Metal Framing” for support framing for insulated core metal wall panels.

B. Division 05 Section “Structural Metal Framing”

C. Division 07 Section “Flashing and Sheet Metal”

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Owner's insurer if applicable, metal panel Installer, metal panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal panels, including installers of doors, windows, and louvers.
2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
3. Review methods and procedures related to metal panel installation, including manufacturer's written instructions.
4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
5. Review flashings, special siding details, wall penetrations, openings, and condition of other construction that affect metal panels.

6. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
7. Review temporary protection requirements for metal panel assembly during and after installation.
8. Review procedures for repair of metal panels damaged after installation.
9. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
2. Accessories: Include details of the flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches (1:10).

C. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.

1. Include similar Samples of trim and accessories involving color selection.

D. Samples for Verification: For each type of exposed finish, prepared on Samples of size indicated below.

1. Metal Panels: 12 inches (305 mm) long by actual panel width. Include fasteners, closures, and other metal panel accessories.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each product, tests performed by a qualified testing agency.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical metal panel assembly as shown on Drawings, including corner, and louver supports, attachments, and accessories.
2. Water-Spray Test: Conduct water-spray test of metal panel assembly mockup, testing for water penetration according to AAMA 501.2.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.10 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.11 COORDINATION

A. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including rupturing, cracking, or puncturing.
b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E72:

1. Wind Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.
3. Deflection Limits: For wind loads, no greater than [1/180].

B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) when tested according to ASTM E283 at the following test-pressure difference:

1. Test-Pressure Difference: 1.57 lbf/sq. ft. (75 Pa).

C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E331 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Fire-Test-Response Characteristics: Provide metal wall panels and system components with the following fire-test-response characteristics, as determined by testing identical panels and system components per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.

1. Fire-Resistance Characteristics: Provide materials and construction tested for fire resistance per ASTM E119.
2. Intermediate-Scale Multistory Fire Test: Tested mockup, representative of completed multistory wall assembly of which wall panel is a part, complies with NFPA 285 for test method and required fire-test-response characteristics of exterior non-load-bearing wall panel assemblies.
3. Radiant Heat Exposure: No ignition when tested according to NFPA 268.
4. Potential Heat: Acceptable level when tested according to NFPA 259.
5. Surface-Burning Characteristics: Provide wall panels with a flame-spread index of 25 or less and a smoke-developed index of 450 or less, per ASTM E84.

2.2 FOAMED-INSULATION-CORE METAL WALL PANELS

A. General: Provide factory-formed and -assembled metal wall panels fabricated from two metal facing sheets and insulation core foamed in place during fabrication, and with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.

1. Insulation Core: Modified isocyanurate or polyurethane foam using a non-CFC blowing agent, with maximum flame-spread and smoke-developed indexes of 25 and 450, respectively.

a. Closed-Cell Content: 90 percent when tested according to ASTM D6226.
b. Density: 2.0 to 2.6 lb/cu. ft. (32 to 42 kg/cu. m) when tested according to ASTM D1622.
c. Compressive Strength: Minimum 20 psi (140 kPa) when tested according to ASTM D1621.
d. Shear Strength: 26 psi (179 kPa) when tested according to ASTM C273/C273M.

B. Concealed-Fastener, Foamed-Insulation-Core Metal Wall Panels Formed with tongue-and-groove panel edges; designed for sequential installation by interlocking panel edges and mechanically attaching panels to supports using concealed clips or fasteners.

C. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. CENTRIA Architectural Systems.
b. MBCI.
c. Metl-Span.

D. Basis of Design: **CENTRIA, Formawall Dimension Series Insulated Core Metal Wall Panels**. Provide basis of design product or comparable product approved by Architect prior to bid.

a. CENTRIA Architectural Systems; Moon Township, PA 15108-2944. Tel: (800)759-7474. Tel: (412)299-8000. Fax: (412)299-8317. Email: info@CENTRIA.com. Web: www.CENTRIA.com.

E. PANEL MATERIAL

1. Stainless-Steel-Face Sheet: ASTM A 666, Type 3204 architectural grade alloy.
   a. Face Sheet Thickness: 0.030 inch/22 gage (0.76.mm)
   b. Surface: Smooth, flat
   c. Finish: Brushed, No. 4

F. FOAMED-INSULATION-CORE METAL WALL PANELS

1. Foamed-Insulation-Core Metal Wall Panels: Halogen-Free, Factory-foamed-in-place horizontal and / or vertical wall panel system consisting of an exterior metal face sheet with interior metal liner panel forming a thermally separated profile, bonded to factory foamed-in-place core, and with factory-sealed tongue-and-groove and rainscreen-designed pressure-equalized horizontal side joint, configured with weep-hole-vented chamber to maintain equalized atmospheric pressure reducing potential for moisture drive into wall assembly, attached to supports using concealed fasteners.
   1. Exclusions: The following do not meet the requirements of this Section:
      a. Laminated panels.
      b. Barrier wall-designed systems.
      c. Systems relying upon venting only at vertical joints to attain pressure equalization.
      d. Systems relying upon field-installed gaskets or wet seals to meet performance requirements.
      e. Panels that contain Halogenated Fire Retardants

2. Horizontal Panel - Side Joint: Side joints with positive drip edge, sloped drain shelf and integral venting to the exterior along the panel length to permit moisture drainage and to allow air to enter the pressure equalization chamber. Side joints shall have a 23/8-inch baffle interlock and shall provide effective pressure equalization as demonstrated by testing specified in 1.4.F.

3. Horizontal Panel - End Joint: End joints for insulated metal panels shall be designed to allow moisture to be drained from the panel's side joint. No end dam sealant is to be applied to the ends of the side joint at the end joint location.

   a. Backer Flash - A continuous back-up flash behind the end joint is required with two beads of field applied non-curing butyl sealant between the panel and back up flashing for each panel. The field applied non-curing butyl sealant shall be married to the panel's shop applied non-curing butyl sealant within the panel's side joint.
   b. Insulated Metal Vertical Joint (IMV) - End joint shall include an integrated, Insulated Metal Vertical Joint. The Insulated Metal Vertical Joint shall be recessed

1-3/16" deep and be 5/8"wide. The Insulated Metal Vertical Joint should not add exterior sightlines, contain exposed metal edges or exposed wet seals. The Insulated Metal Vertical Joint shall be constructed of an EPDM Foam Block adhered to a metal face of the same material, gage and color as the face of the panel.

Panel Ends: Flat - Factory formed trimless ends, tabbed under panel horizontal shelf .

4. Panel Width: 10" (254 mm) - 40" (1016 mm).
    1. Min. Segment Length = 12”

5. Panel Profile: Flat in locations and sizes indicated.

6. Panel Thickness: 2.0 inch (51 mm), flat.

2.3 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Subframing and Furring: ASTM C645, cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 (Z275 hot-dip galvanized) coating designation or ASTM A792/A792M, Class AZ50 (Class AZM150) aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.

1. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal panels.
2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

D. Extrusion Trim: Provide manufacturer-provided extruded trim for the following locations and as indicated on Drawings:
    a. Base Trim
    b. Coping
    c. Panel installation perimeter
    d. Opening perimeters

E. Panel Attachment Clips: Concealed G-90 galvanized steel clip configured to prevent overdriving of fastener and crushing of foam core, with panel fasteners engaging both face and liner elements

and mechanically attaching to panel supports. Clip configured also to be utilized without removing significant portions of the foam at each clip location.

F. Panel Fasteners: Self-tapping screws designed to withstand design loads. Where fasteners are exposed, provide fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.

G. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish. Meet requirements of Division 07 Section "Joint Sealants"

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
2. Joint Sealant: ASTM C920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.
3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.4 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
4. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.

a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

E. INTEGRATED WALL LOUVER UNITS

Manufacturers/Products:

1. Product: **C/S Louvers by Construction Specialties, Inc.**, or approved equal.

2.5 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Metallic-Coated Liner Sheet: Coil-coated, ASTM A755/A 775 M 0.030 inch/22 gage (0.76 mm)

1. Zinc-Coated (Galvanized) Steel Sheet; ASTM A 653/A 653M, G90, structural quality.
2. Surface – Embossed planked
3. Interior Liner Panel finish: 0.2 primer with 0.6 mil acrylic coat.

D. Exterior Finish: Clear Anodic Finish, Architectural Class 1, AAMA 611.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

1. Examine wall framing to verify that girts, angles, channels, studs, and other structural panel support members and anchorage have been installed within alignment tolerances required by metal wall panel manufacturer.
2. Examine wall sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal wall panel manufacturer.

a. Verify that air- or water-resistive barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
b. Maximum deviations acceptable:
1) 1/4-inch in 20 feet (6.4 mm in 6 m) vertically or horizontally from face plane of framing.
2) 1/2-inch (12.7 mm) from flat substrate on any building elevation.
3) 1/8-inch in 5 feet (3.2 mm in 1.5 m).

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

C. Framing: Inspect framing that will support metal wall panels to determine if support components are installed as indicated on approved shop drawings. Confirm presence of acceptable framing members at recommended spacing to match installation requirements of metal wall panels.

D. Openings: Verify that doors, louvers and other penetrations match layout on shop drawings.

E. Advise G.C., in writing of all out-of-tolerance work and other deficient conditions prior to proceeding with metal wall panel installation.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.

3.3 METAL PANEL INSTALLATION

A. General: Install metal wall panel system in accordance with approved shop drawings and manufacturer's recommendations. Install metal wall panels in orientation, sizes, and locations indicated. Anchor metal wall panels and other components securely in place. Provide for thermal and structural movement

B. Attach panels to metal framing using recommended clips, screws, fasteners, sealants, and adhesives indicated on approved shop drawings.
   1. Fasteners for Steel Wall Panels: Stainless-steel for exterior locations and locations exposed to moisture; carbon steel for interior use only.
   2. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated or, if not indicated, as approved by manufacturer.
   3. Fasten metal wall panels to supports with concealed clips at each joint at location, spacing, and with fasteners recommended by manufacturer. Install clips to supports with self-tapping fasteners.
   4. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.
   5. Horizontal Joinery: Working from base of installation to top connect upper panel to lower panel at dry seal joinery.
   6. Vertical Joinery: Provide reveal between vertical ends of panels as shown on shop drawings using hardware and gaskets furnished by manufacturer to form a weather tight seal between panels.
   7. Dissimilar Materials: Where elements of metal wall panel system will come into contact with dissimilar materials, treat faces and edges in contact with dissimilar materials as recommended by manufacturer.

C. Fasteners:

1. Steel Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.

D. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

E. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal wall panel assemblies.

1. Seal panel end utilizing 2 beads of non-curing butyl aligning with factory-applied seal in adjacent panel pocket; apply continuously without gaps to complete panel system air barrier.
2. Seal metal wall panel to supports or back-up flashing sealant, full width of panel. Seal side joints where recommended by metal wall panel manufacturer. Do not install sealant in locations that will interfere with drainage of pressure-equalized panel chambers.
3. Prepare joints and apply sealants per Division 07 Section "Joint Sealants."

F. Foamed-Insulation-Core Metal Wall Panels: Fasten metal wall panels to supports with concealed clips at each joint at location and spacing and with fasteners recommended by manufacturer. Fully engage tongue and groove of adjacent panels.

1. Install clips to supports with self-tapping fasteners.

3.4 INTEGRATED UNIT INSTALLATION

A. Install louvers in accordance with manufacturer's recommendations and approved shop drawings. Anchor supports to structure with approved anchors. Assemble wall components using gaskets, fasteners, and trim supplied by metal wall panel manufacturer. Separate dissimilar metals with manufacturer's approved coating.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Water-Spray Test: After installation, test area of assembly shown on Drawings for water penetration according to AAMA 501.2.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed metal wall panel installation, including accessories.

D. Metal wall panels will be considered defective if they do not pass test and inspections.

E. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

F. Final AAMA 501.2 testing will be conducted by an independent test agency following project completion. Areas of test are to be determined by the Architect/Engineer and General Contractor/Contract Manager and the panel installer. Engagement of the test agency is the

responsibility of the GC/CM. A field representative from the panel manufacturer is required for the final inspection and testing.

G. Prepare test and inspection reports.

3.6 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. After metal panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

C. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 074213.19