Laney Library & Learning Resource Center
(Building 100 Replacement)

900 Fallon Street
Oakland, California

PROJECT MANUAL - VOLUME 2

50% CONSTRUCTION DOCUMENTS
DSA Application XX-XXXXXX

August 24, 2020

Noll & Tam Architects
729 Heinz Avenue
Berkeley, CA 94710
510.542.2200

Mark Cavagnero Associates
1045 Sansome St, Suite 200
San Francisco, CA 94111
415.398.6944

SECTION 000110

TABLE OF CONTENTS

VOLUME 1

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP:

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 211313

WET-PIPE SPRINKLER AND STANDPIPE SYSTEMS

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. This Section includes the following fire-suppression piping inside the building:

1. Wet pipe sprinkler systems.
2. Standpipe and hose connection system.

B. Drawings supplied with this specification shall be used as a reference for the requirement and general location of system components.

C. At the time of bid, all exceptions taken to these Specifications, variances from these Specifications and all substitutions of equipment specified shall be listed in writing and forwarded to Peralta Community College District (Owner). Any such exceptions, variances, or substitutions, which were not listed at the time of bid shall not be approved or considered.

D. The Work includes all labor, materials, tools, transportation, temporary demolition, and temporary construction necessary to design, fabricate, install, test and flush a fully operational and code compliant automatic sprinkler system throughout the library building as indicated on the drawings that includes:

1. Fire protection mains and risers.
2. Electrically supervised indicating control valves.
3. Check valves.
4. Pressure gauges.
5. Flow and supervisory switches.
6. Overhead pipe, fittings, hangers and sprinklers.
7. Inspector's test connections, main drains and auxiliary drains.
8. Fire-stopping for all openings associated with this Work.

E. The Work includes all fees and activities required to secure approvals for necessary State and Local permits.

F. The Work includes preparing and submitting detailed Working Plans, Hydraulic Calculations and Product Data to the Owner for review prior to submitting same to local officials for approval and permit.

G. The Work includes performing field quality control activities.

H. The Work includes documenting and submitting the results of integrity and functional testing.

I. The Work includes performing overall system "Owner Demonstration" test(s) for the Owner's approval.

J. The Work includes performing overall system "Final Authority Acceptance" test(s) for Authority approval.

K. The Work includes preparing and submitting Closeout Documentation including As-built Plans to the Owner.

L. The Work includes training Owner's facilities personnel on the operation of the system, required maintenance tasks and frequencies, and the locations of all spare tools and equipment, valves, flow switches, risers and equipment necessary to maintain and operate the sprinkler system.

1.3 DEFINITIONS

A. Underground Service-Entrance Piping: Underground service piping below the building.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.5 PERFORMANCE REQUIREMENTS

A. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent or 5 PSI, whichever is greater, including losses through water-service piping, valves, and backflow preventers.

2. Sprinkler Occupancy Hazard Classifications:

a. All areas except those identified below: Light Hazard.
b. Storage & Mechanical Spaces: Ordinary Hazard

3. Minimum Density for Automatic-Sprinkler Piping Design:

a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft.
b. Ordinary Hazard: 0.15 gpm over 1500-sq. ft.

4. Maximum Protection Area per Sprinkler (unless otherwise indicated as "extended coverage" on design drawings):

a. Light Hazard: 225 sq. ft.
b. Ordinary Hazard: 130 sq. ft.

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:

a. Light Hazard: 100 gpm for 30 minutes.
b. Ordinary Hazard: 250 gpm for 60 to 90 minutes.

6. The standpipe system shall deliver 500 gpm at the two most hydraulically remote standpipe connections at a residual pressure of 100 psi. Each additional standpipe shall have a flow rate of 250 gpm at a residual pressure of 100 psi.

1.6 ORDER OF PRECEDENCE

A. Should conflicts arise out of discrepancies between documents referenced in this specification, the most stringent requirement shall apply; however, should a level of stringency be indeterminable, the discrepancies shall be resolved as follows:

1. State and local codes shall take precedence over this specification.
2. The National Fire Protection Association Standards shall take precedence over this specification.
3. Drawing specific requirements as documented on the RFP drawing package.

1.7 SUBMITTALS

A. Product Data: For the following:

1. Piping materials, including dielectric fittings, and sprinkler specialty fittings.
2. Pipe hangers and supports.
3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
4. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
5. Hose connections, including size, type, and finish.
6. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
7. Alarm devices, including electrical data.

B. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, details, and attachment to other work.
2. Include diagrams for power, signal, and control wiring.

C. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.
2. Compressed air piping.
3. HVAC hydronic piping.
4. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.

D. Fire-hydrant flow test report.

E. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

G. Welding certificates.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.8 AS-BUILT (RECORD) DRAWINGS

A. On a daily basis the contractor's superintendent shall record as built conditions on a set of Shop Drawings maintained at the job site. Three sets of Shop Drawings reflecting as built conditions shall be available prior to and for use in the final acceptance test. Two weeks after the acceptance test and before final acceptance of the work, furnish three complete sets of as built drawings. The drawings shall be prepared on uniform sized sheets not less than 36 by 48 inches in size. In addition, provide a USB flash drive containing AutoCAD (Version to be coordinated with Owner) DWG and PDF format of all as built drawings and schematics. The drawings shall include:

1. As built location of all devices and equipment.
2. Riser diagram.
3. All deviations from the project drawings and approved shop drawings.

1.9 QUALITY ASSURANCE

A. Equipment and devices shall be labeled and listed for the intended use in the Underwriters Laboratories, Inc. (UL), UL FPED *Fire Protection Equipment Directory*.

B. Electrical components, devices, and accessories shall be Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction.

C. All materials and equipment shall be new and unused.

D. All equipment shall be first quality and capable of complying with all requirements of this specification and shall have been in continuous production and in service in commercial applications for at least one year. Obsolete equipment shall not be used.

E. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Installer shall base calculations on results of fire-hydrant flow test.

    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
    b. Foreman: Provide proof of competence of both their company and the individual foreman that will be assigned to this project, in the area of installing automatic fire sprinkler systems for at least five (5) years and acceptable to Owner. Once assigned, the foreman shall not be changed without the approval of the Owner.
    c. Service Organization: Capable of providing a service technician on-site within 4 hours of a request for on-site service.

F. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

G. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 14, “Installation of Standpipe and Hose Systems.”
3. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

1.10 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Coordinate sprinkler installation with other portions of the Work to comply with NFPA 13 requirements for obstruction to sprinkler discharge.

C. Coordinate pipe installation with other portions of the Work to facilitate proper pitch and accessibility for components installed.

D. Coordinate with the Fire Alarm portion of the Work for the connection and testing of waterflow and valve supervisory switches.

E. Coordinate sprinkler and pipe installation with other trades, etc.

1.11 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

1.12 WARRANTY

A. Guarantee equipment installed to be free from defects in workmanship and inherent mechanical defects for a period of one (1) year from the date of substantial completion of the project.

PART 2 - PRODUCTS

2.1 STEEL PIPE AND FITTINGS

A. Sprinkler piping shall be hydraulically calculated and sized, using actual C factors for the material used. These computer calculations shall be submitted for approval as a part of the shop drawing submittal.

B. Standard-Weight, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

C. Steel Pipe: Piping 2 ½" and smaller shall be Schedule 40 black steel. Piping larger than 2 ½" shall be Schedule 40 or Schedule 10 black steel.

D. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

E. Uncoated-Steel Couplings: ASTM A 865/A 865M, threaded.

F. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

G. Malleable- or Ductile-Iron Unions: UL 860.

H. Cast-Iron Flanges: ASME 16.1, Class 125.

I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

J. Grooved-Joint, Steel-Pipe Appurtenances:

1. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.
2. Grooved-Joint, Steel-Pipe Appurtenances:
3. Pressure Rating: 175-psig minimum.

K. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

L. All fittings on suction side of pump shall be flanged; remaining pump room fittings may be flanged, screwed, grooved or welded as permitted by NFPA 20.

M. Remaining fittings on steel pipe may be welded, screwed or grooved; galvanized fittings shall be used on galvanized pipe. The used of plain end fittings is prohibited.

2.2 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating and made of materials compatible with piping.

B. Outlet Specialty Fittings:

1. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.

C. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.

D. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.

E. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.

2.3 UL LISTED FIRE-PROTECTION VALVES

A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating.

B. Ball Valves: Comply with UL 1091, except with ball instead of disc.

1. NPS 1-1/2 and Smaller: Bronze body with threaded ends.
2. NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
3. NPS 3: Ductile-iron body with grooved ends.

C. Butterfly Valves: UL 1091.

1. NPS 2 and Smaller: Bronze body with threaded ends.
2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.

D. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.

E. Gate Valves: UL 262, OS&Y type.

1. NPS 2 and Smaller: Bronze body with threaded ends.
2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.

F. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.

1. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.
2. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.

G. Alarm Valves:
1. Standard: UL 193.
2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, and fill-line attachment with strainer.
4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
6. 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.

H. Deluge Valves:
1. Standard: UL 260.
2. Design: Hydraulically operated, differential-pressure type.
3. Include trim sets for alarm-test bypass, drain, electrical water-flow alarm switch, pressure gauges, drip cup assembly piped without valves and separate from main drain line, and fill-line attachment with strainer.
4. Wet, Pilot-Line Trim Set: Include gauge to read diaphragm-chamber pressure and manual control station for manual operation of deluge valve, and connection for actuation device.

2.4 UNLISTED GENERAL-DUTY VALVES

A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.

B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.

C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.

D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.5 SPECIALTY VALVES

A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating.

1. Riser Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for drain and pressure gauges.

B. Automatic (ball drip) Drain Valves: UL 1726, NPS 3/4, ball-check device with threaded ends.

2.6 MANUAL CONTROL STATIONS

A. Manual Control Stations: UL listed or FMG approved, hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.7 SPRINKLERS

A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating.

B. Sprinklers shall be of a type, style and specification as indicated on the drawings. Heads shall be heavy duty type and installed either exposed or concealed per Architect's design.

C. Student toilet rooms shall be provided with concealed flush to ceiling style heads having a painted cover plate, per Architect's design.

D. Operating Element: Quick Response (QR) as indicated or required by application.

E. Sprinkler types, features, and options as follows:

1. Pendent sprinklers.
2. Upright sprinklers.
3. Sidewall sprinklers

F. Available Manufacturers

1. Star Sprinkler Inc.
2. Central Sprinklers Inc.
3. Viking Corp.

2.8 FIRE DEPARTMENT CONNECTIONS

A. Two-Way, Exposed Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and marking similar to "AUTO SPKR and Standpipe"

1. Type: two-way, exposed, with two inlets and square or rectangular escutcheon plate.
2. Finish: Polished brass.

B. Fire Department Hose Valves: 2-1/2-inch hose valves for fire department use shall be installed in all building stairwells. Valves shall be recessed in approved fire department valve cabinets, where applicable.

2.9 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Electrically Operated Alarm: UL 464, with an approved diameter for the City of Oakland, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.

C. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.

D. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

2.10 PRESSURE GAUGES

A. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gauge with range of 0 to 250 psig minimum.

1. Water System Piping: Include caption "WATER" on dial face.

2.11 SIGNS

A. Steel with vitreous enamel finish, lettering on contrasting background to identify and indicate the function of:

1. Control valves.
2. Drain, test, air supply and alarm check valves.
3. Hydraulic Design Nameplate Data: Size approx. 9 x 12 inches, inscribed with the following:

a. SPRINKLER SYSTEM HYDRAULICALLY DESIGNED (in block letters).
b. Location and area of hydraulically designed section.
c. Discharge density over designed area in gallons per minute.
d. Residual pressure at base of riser supplying water to designed section.

2.12 HANGERS

A. Pipe hangers and anchoring means shall be designed in accordance with NFPA 13.

B. Pipe shall be supported with clevis-type or swivel ring hangers of steel constructional hangers shall be UL listed for their intended use.

C. Hangers shall be supported directly by building structure by listed expansion anchors, beam clamps, center load clamps, wall brackets, concrete inserts, wood screws/fasteners or other approved hanging systems certified by a professional engineer to support the sprinkler piping as required by NFPA 13 and all other supported loads.

D. Hangers shall account for all seismic loading on system piping.

E. Only sprinkler or standpipe piping may be supported by sprinkler/standpipe system hangers; no other utilities, equipment or devices shall be supported by sprinkler hangers or piping.

PART 3 - EXECUTION

3.1 PREPARATION

A. Fire-hydrant flow test shall be provided in accordance with NFPA 13 and NFPA 291. Flow test data shall not be more than six months old.

B. Report test results promptly and in writing.

3.2 PIPING APPLICATIONS, GENERAL

A. Welded piping must be shop welded. Other pipe and fitting materials and other joining methods must also be specified to permit field assembly of shop-welded piping.

1. Shop weld pipe joints where welded piping is indicated.
2. Do not use welded joints for galvanized-steel pipe.
3. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.
4. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast- or malleable-iron threaded fittings; and threaded or grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
5. Underground Service-Entrance Piping: Ductile-iron, mechanical-joint pipe and fittings and restrained joints. Include corrosion-protective encasement.

3.3 SPRINKLER SYSTEM PIPING APPLICATIONS

A. If more than one type of material and joining method is used for a particular pipe size, identify materials on Drawings and show points of transition from one material to another.

1. Standard-Pressure, Wet-Pipe Sprinkler System, 175-psig Maximum Working Pressure:

a. Sprinkler-Piping Fitting Option: Specialty sprinkler fittings, NPS 2-1/2 and smaller, including mechanical-T and -cross fittings, may be used downstream from sprinkler zone valves.
b. NPS 2: Threaded-end, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
c. NPS 2-1/2 to NPS 6: Grooved-end, standard-weight steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.4 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13.

    a. Shutoff Duty: Use ball, butterfly, or gate valves.

2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13.

    a. Shutoff Duty: Use ball, butterfly, or gate valves.
    b. Throttling Duty: Use ball or globe valves.

3.5 JOINT CONSTRUCTION

A. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads.

B. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.

1. Steel Pipe: Square-cut. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.

C. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.

1. NPS 2 and Smaller: Use dielectric unions, couplings, or nipples.
2. NPS 2-1/2 to NPS 4: Use dielectric flanges.
3. NPS 5 and Larger: Use dielectric flange insulation kits.

3.6 SERVICE-ENTRANCE PIPING

A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building. Refer to Division 22 Section "Facility Water Distribution Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping. Refer to Division 22 Section "Facility Water Distribution Piping" for backflow preventers.

C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water service.

3.7 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction and the Owner. File written approval with Architect before deviating from approved working plans

2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

F. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. All piping shall be installed at a height so as not to obstruct any portion of a window, doorway, stairway or a passageway, and shall not interfere with the operation of any mechanical or electrical equipment.

J. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

K. Install alarm devices in piping systems.

L. Hangers and Supports: Comply with NFPA 13 for hanger materials.

1. Install sprinkler system piping according to NFPA 13.

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each riser. Include pressure gauges with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal and install where they will not be subject to freezing.

N. Fill wet-pipe sprinkler system piping with water.

3.8 VALVE INSTALLATION

A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Specialty Valves:

1. Riser Check Valves: Install in vertical position for proper direction of flow.

3.9 SPRINKLER APPLICATIONS

A. Sprinklers are to be provided and installed as indicated on the drawings.

B. All public and occupant areas shall be equipped with concealed sprinklers with non-painted metallic cover plates.

C. All mechanical, closet, storage and plenum spaces shall use brass finish sprinklers.

3.10 SPRINKLER INSTALLATION

A. Install sprinklers in accordance with NFPA 13 and in the general patterns indicated on the submitted Working Drawings.

B. The contractor shall be responsible for furnishing additional sprinklers and piping to provide additional coverage that may be required to avoid lights and diffusers not indicated on the drawings.

C. Contractor responsible for relocating lights, if necessary to accommodate the contractors shop drawings, if the lights constitute an obstruction to sprinkler pattern development in accordance with NFPA 13.

D. Provide recessed pendent sprinklers with white finish centered in the width of ceiling tiles. Pendant sprinklers located in 4-foot long ceiling tiles may be installed only at the mid or quarter points of the tile's long side.

E. Do not install sprinklers, mains or branchline pipes in locations where likely to be inadvertently damaged, such as in front of access hatches, doors, cabinets, etc.

3.11 FIRE DEPARTMENT CONNECTIONS

A. Install two-way, exposed, fire department connections.

B. Install ball drip valve at each check valve for fire department connection.

3.12 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect water-supply piping to fire-suppression piping. Include backflow preventer between potable-water piping and fire-suppression piping.

D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

E. Connect piping to specialty valves, specialties, fire department connections, and accessories.

F. Connect alarm devices to fire alarm.

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.13 LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

3.14 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Energize circuits to electrical equipment and devices.
4. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
5. Coordinate with fire alarm tests. Operate as required.
6. Verify that equipment hose threads are same as local fire department equipment.

B. Report test results promptly and in writing to Owner and authorities having jurisdiction.

3.15 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

C. Protect sprinklers from damage until Substantial Completion.

3.16 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

END OF SECTION 211313

SECTION 213113

ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

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. This Section includes electric-drive, split-case centrifugal fire pumps and the following:

1. Full service fire pump controllers.
2. Fire-pump accessories and specialties.
3. Pressure-maintenance pumps, controllers, accessories, and specialties.
4. Fire pump power is provided under a separate contract. Fire pump monitoring and alarms are furnished by the Electrical Contractor.

B. Drawings supplied with this specification shall be used as a reference for the requirement and general location of system components. Work includes visiting the site to observe the existing conditions, and confirmation of the required quantities of devices and specific options for locations of the same.

C. At the time of bid, all exceptions taken to these Specifications, variances from these Specifications and all substitutions of equipment specified shall be listed in writing and forwarded to Peralta Community College District (Owner). Any such exceptions, variances, or substitutions, which were not listed at the time of bid shall not be approved or considered.

D. The Work includes all labor, materials, tools, transportation, temporary demolition, and temporary construction necessary to design, fabricate, install, and test a fully operational and code compliant electric fire pump and controller for the library building as indicated on the drawings.

E. The Work includes all fees and activities required to secure approvals for necessary State and Local permits.

F. The Work includes preparing and submitting detailed Working Plans, Hydraulic Calculations and Product Data to the Owner for review prior to submitting same to local officials for approval and permit.

G. The Work includes performing field quality control activities.

H. The Work includes documenting and submitting the results of integrity and functional testing.

I. The Work includes performing overall system, half-day “Owner Demonstration” test(s) for the Owner’s approval.

J. The Work includes performing overall system, half-day “Final Authority Acceptance” test(s) for Authority approval.

K. The Work includes preparing and submitting Closeout Documentation including As-built Plans to the Owner.

L. The Work includes training Owner’s facilities personnel on the operation of the system, required maintenance tasks and frequencies, and the locations of all spare tools and equipment necessary to maintain and operate the system.

1.3 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to NFPA and the California Fire Code.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified [and the unit will be fully operational after the seismic event]."
2. Component Importance Factor: 1.5

C. Pump, Equipment, Accessory, Specialty, and Piping Pressure Rating: 175-psig minimum working-pressure rating, unless otherwise indicated.

1.4 ORDER OF PRECEDENCE

A. Should conflicts arise out of discrepancies between documents referenced in this specification, the most stringent requirement shall apply; however, should a level of stringency be indeterminable, the discrepancies shall be resolved as follows:

1. State and local codes shall take precedence over this specification.
2. The National Fire Protection Association Standards shall take precedence over this specification.
3. Drawing specific requirements as documented on the RFP drawing package.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, certified pump performance curves with each selection point indicated, operating characteristics, and furnished accessories and specialties for each fire pump and pressure-maintenance pump. Products may include but are not limited to:

1. Pumps
2. Pump controllers
3. Motor
4. Air-release valves
5. Circulation relief valves
6. Pressure gauges
7. Eccentric reducers

8. Concentric reducers
9. Pressure-maintenance pumps
10. Enclosures
11. Control valves
12. Sensing lines
13. Flow meters

B. Shop Drawings: For fire pumps and drivers, fire-pump controllers, fire-pump accessories and specialties, pressure-maintenance pumps, pressure-maintenance-pump controllers, and pressure-maintenance-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Product Certificates: For each type of fire pump and fire-pump controller, signed by product manufacturer.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For fire pumps and drivers, pressure-maintenance pumps, controllers, accessories and specialties, alarm panels, and flowmeter systems to include in emergency, operation, and maintenance manuals.

1.6 AS-BUILT (RECORD) DRAWINGS

A. On a daily basis the contractor's superintendent shall record as built conditions on a set of Shop Drawings maintained at the job site. Three sets of Shop Drawings reflecting as built conditions shall be available prior to and for use in the final acceptance test. Two weeks after the acceptance test and before final acceptance of the work, furnish three complete sets of as built drawings. The drawings shall be prepared on uniform sized sheets not less than 36 by 48 inches in size. In addition, provide a USB flash drive containing AutoCAD (Version to be coordinated with Owner) DWG and PDF format of all as built drawings and schematics. The drawings shall include:

1. As built location of all devices and equipment.
2. As built schematics of electrical service connections
3. All deviations from the project drawings and approved shop drawings.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain fire pumps, pressure-maintenance pumps, and controllers through one source from a single manufacturer for each type of equipment.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of fire pumps, pressure-maintenance pumps, and controllers and are based on specific systems indicated.

C. Equipment and devices shall be labeled and listed for the intended use in the Underwriters Laboratories, Inc. (UL), UL FPED *Fire Protection Equipment Directory*.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. All materials and equipment shall be new and unused.

F. All equipment shall be first quality and capable of complying with all requirements of this specification and shall have been in continuous production and in service in commercial applications for at least one year. Obsolete equipment shall not be used.

G. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire hydrant flow test.

    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
    b. Foreman: Provide proof of competence of both their company and the individual foreman that will be assigned to this project, in the area of installing automatic fire sprinkler systems for at least five (5) years and acceptable to Owner. Once assigned, the foreman shall not be changed without the approval of the Owner.
    c. Service Organization: Capable of providing a service technician on-site within 4 hours of a request for on-site service.

H. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

I. Comply with NFPA 20, "Stationary Pumps for Fire Protection," for fire pumps, drivers, controllers, accessories, and their installation.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Pad and grouting of the pump base is by the Fire Protection Contractor.

1.9 WARRANTY

A. Guarantee equipment installed to be free from defects in workmanship and inherent mechanical defects for a period of one (1) year from the date of substantial completion of the project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified in Section 2.2 C1.

2.2 CENTRIFUGAL FIRE PUMPS

A. Description, General: UL 448, factory-assembled and -tested, electric-drive, centrifugal fire pumps capable of furnishing not less than 150 percent of rated capacity at not less than 65 percent of total rated head and with shutoff head limited to 5 percent of total rated head.

1. Finish: Manufacturer's standard red paint applied to factory-assembled and -tested unit before shipping.
2. Nameplate: Complete with capacities, characteristics, and other pertinent data.

B. Fabricate base and attachment to fire pumps, pressure-maintenance pumps, and controllers with reinforcement to resist movement of pumps and controllers during a seismic event when their bases are anchored to building structure.

C. Single-Stage, Vertical In-Line Fire Pumps: End suction type with pump and driver mounted on same base and connected with coupling.

1. Available Manufacturers:

a. A-C Pump; ITT Industries.
b. Armstrong Darling, Inc.
c. Aurora Pump; Pentair Pump Group.
d. Fairbanks Morse; Pentair Pump Group.
e. Paco Pumps, Inc.
f. Patterson Pump Company.
g. Reddy-Buffaloes Pump Co.
h. Sterling Peerless Pump; Sterling Fluid Systems Group.

2. Pump: Axially split cast-iron casing with suction and discharge flanges machined to ASME B16.1, Class 125 dimensions, unless otherwise indicated.

a. Impeller: Cast bronze of construction to match fire pump, statically and dynamically balanced, and keyed to shaft.
b. Wear Rings: Replaceable, bronze.
c. Shaft and Sleeve: Steel shaft with bronze sleeve.

1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

3. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
4. Driver: UL-listed, NEMA MG 1, open-drip proof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.

D. Fire-Pump Characteristics and Specialty Data:

1. The following Fire Pump Criteria will be determined in the design process. Fire-Pump Plan on Sheet No. tbd.

    a. Rated Capacity: tbd gallons per minute.
    b. Total Rated Head: tbd pounds per square inch.
    c. Inlet Size: tbd
    d. Outlet Size: tbd
    e. Outlet Flange Class 125.

2. Speed: Same as driver.
3. Electric-Motor Driver: tbd HP, tbd RPM, 3 Phase, 60 Hz, tbd Volts.
4. Test Header Size: tbd inch.
5. Hose Valves Required: tbd.
6. Hose Valve Size: NPS 2 ½ inches.

2.3 FIRE-PUMP CONTROLLERS

A. Fire-Pump Controllers, General: UL 218 and NFPA 20; listed for electric-drive, fire-pump service and service entrance; combined automatic and manual operation; factory assembled and wired; and factory tested for capacities and electrical characteristics.

1. Available Manufacturers:

    a. Firetrol, Inc.
    b. Hubbell Industrial Controls, Inc.
    c. Joslyn Clark.
    d. Master Control Systems, Inc.
    e. Metron, Inc.

2. Rate controllers for scheduled fire-pump horsepower and short-circuit withstand rating at least equal to short-circuit current available at controller location. Take into account cable size and distance from substation or supply transformers.
3. Enclosure: UL 50, Type 2, drip proof, indoor, unless special-purpose enclosure is indicated. Include manufacturer's standard red paint applied to factory-assembled and -tested unit before shipping.
4. Controls, devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used, and specific items listed.

    a. Isolating means and circuit breaker.
    b. "Power on" pilot lamp.
    c. Fire-alarm system connections for indicating motor running condition, loss-of-line power, and line-power phase reversal.
    d. Automatic and manual operation, and minimum run-time relay to prevent short cycling.
    e. Water-pressure-actuated switch with independent high and low calibrated adjustments responsive to water pressure in fire-suppression piping.
    f. Automatic and manual shutdown.
    g. System pressure recorder, electric ac driven with spring backup.

5. Nameplate: Complete with capacity, characteristics, approvals and listings, and other pertinent data.
6. Controller Sensing Pipes: Fabricate pipe and fittings according to NFPA 20 with nonferrous-metal sensing piping, NPS 1/2, with globe valves for testing controller mechanism from system to pump controller as indicated. Include bronze check valve with 3/32-inch orifice in clapper or ground-face union with noncorrosive diaphragm having 3/32-inch orifice.

B. Full-Service Fire-Pump Controllers:

1. Type Starting: Across the line.
2. Mounting: Floor stand type for field electrical connections.

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Match fire-pump suction and discharge ratings as required for fire-pump capacity rating. Include the following:

1. Automatic air-release valve.
2. Circulation relief valve.
3. Suction and discharge pressure gauges.
4. Eccentric-tapered reducer at suction inlet.
5. Concentric-tapered reducer at discharge outlet.
6. Test-Header Manifold: Ductile-iron, cast steel or brass body for hose valves, hemispherical in construction, with sufficient number of 2 ½" valves, UL listed and capable of the designed flow in gallons per minute.
7. Hose Valves: UL 668, straightway pattern, and bronze. Include NFPA 1963 hose thread that complies with local fire department standards and finish same as for test-header manifold escutcheon plate. Valves will be in place only for pump testing; provide caps for openings when valves are stored.
8. Ball Drip Valve: UL 1726.
9. Finish: Manufacturer's standard factory-applied red paint unless brass or other finish is specified.

2.5 PRESSURE-MAINTENANCE PUMPS

A. Pressure-Maintenance Pumps, General: Factory-assembled and -tested pumps with electric-motor driver, controller, and accessories and specialties. Include cast-iron or stainless-steel casing and bronze or stainless-steel impellers, mechanical seals, and suction and discharge flanges machined to ASME B16.1, Class 125 dimensions unless Class 250 flanges are indicated and except that connections may be threaded in sizes where flanges are not available.

1. Finish: Manufacturer's standard color paint applied to factory-assembled and -tested unit before shipping.
2. Nameplate: Complete with capacity, characteristics, and other pertinent data.

B. Regenerative-Turbine, Pressure-Maintenance Pumps: Close-coupled type complying with HI 1.1-1.2 and HI 1.3 requirements for regenerative-turbine centrifugal pumps. Include base.

1. Available Manufacturers:

a. Aurora Pump; Pentair Pump Group.
b. Crane Pumps & Systems, Inc.
c. Fairbanks Morse; Pentair Pump Group.
d. MTH Tool Co., Inc.
e. Paco Pumps, Inc.

2. Driver: NEMA MG 1, open-drip proof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.

C. Controllers: UL 508; factory-assembled, -wired, and -tested, across-the-line type for combined automatic and manual operation.

1. Available Manufacturers:

a. Firetrol, Inc.
b. Hubbell Industrial Controls, Inc.
c. Joslyn Clark.
d. Master Control Systems, Inc.
e. Metron, Inc.

2. Enclosure: UL 508 and NEMA 250, Type 2, wall-mounting type for field electrical wiring.

a. Finish: Manufacturer's standard color paint applied to factory-assembled and -tested unit before shipping.

3. Rate controller for scheduled horsepower and include the following:

a. Fusible disconnect switch.
b. Pressure switch.
c. Hand-off-auto selector switch.
d. Pilot light.
e. Running period timer.

D. Accessories and Specialties: Match pressure-maintenance-pump suction and discharge ratings as required for pump capacity rating. Include the following:

1. Circulation relief valve.
2. Suction and discharge pressure gauges.

E. The following Fire Pump Criteria will be determined in the design process. Pressure-Maintenance-Pump Characteristics and Specialty Data:

1. Rated Capacity: tbd gpm.
2. Total Rated Pressure: tbd psi.
3. Electric-Motor Driver Size: Approximately tbd HP, 3 Phase, 60 Hz, tbd Volts.

2.6 PRESSURE GAUGES

A. Description: UL 393, 3-1/2- to 4-1/2-inch- (90- to 115-mm-) diameter dial with range of 0-250 psig (0- to 1725-kPa) (0- to 2070-kPa) minimum. Include caption "WATER" on dial face.

1. Available Manufacturers:

a. AGF Manufacturing Co.
b. AMETEK, Inc.; U.S. Gauge.
c. Brecco Corporation.
d. Dresser Equipment Group; Instruments Div.
e. Marsh Bellofram.
f. WIKA Instrument Corporation.

2.7 GROUT

A. Description: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect fire pumps with their controllers according to NFPA 20 for certified shop tests.

B. Verification of Performance: Rate fire pumps according to requirements indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, concrete bases, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of fire pumps.

B. Examine roughing-in for fire-suppression piping to verify actual locations of piping connections before fire-pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for fire pumps, pressure-maintenance pumps, and controllers.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch(450-mm) centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are provided by the Fire Protection Contractor.

3.3 INSTALLATION

A. Install and align fire pump, pressure-maintenance pump, and controller according to NFPA 20 and manufacturer's instructions.

B. Install pumps and controllers to provide access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Set base-mounting-type pumps on concrete bases. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump baseplate on rectangular metal blocks and shims or on metal wedges having small taper, at points near anchor bolts, to provide 3/4- to 1-1/2-inch gap between pump base and concrete base for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Verify that coupling faces and pump suction and discharge flanges are level and plumb.

D. Install suction and discharge piping equal to or greater than diameter of fire-pump nozzles.

E. Install valves that are same size as piping connecting fire pumps, bypasses, test headers, and other piping systems.

F. Install pressure gauges on fire-pump suction and discharge at pressure-gauge tappings.

G. Support pumps and piping separately so weight of piping does not rest on pumps.

H. Install piping accessories, hangers and supports, anchors, valves, meters and gauges, and equipment supports.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

3.4 ALIGNMENT

A. Align split-case fire-pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connections.

D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

E. Align vertically mounted, split-case pump and driver shafts after complete unit has been made plumb on concrete base, grout has set, and anchor bolts have been tightened.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to point of disposal.

D. Connect controllers to pumps.

E. Connection of the fire-pump controllers to building fire-alarm system is by the Electrical Contractor.

F. Ground equipment according to the California Fire Code and NFPA 70.

G. Connect wiring according to the California Fire Code and NFPA 70.

H. All drain lines are to be piped to the nearest floor drain. Discharge onto the floor will not be accepted.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

B. Perform field tests for fire pump when installation is complete. Comply with operating instructions and procedures in NFPA 20 to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be satisfactorily corrected or that does not perform as indicated, then retest to demonstrate compliance. Verify that each fire pump performs as indicated.

C. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Final Checks before Startup: Perform the following preventive-maintenance operations and checks:

    a. Lubricate oil-lubrication-type bearings.
    b. Remove grease-lubrication-type bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's written instructions.
    c. Disconnect coupling and check electric motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
    d. Verify that pump is free to rotate by hand. If pump is bound or if it drags even slightly, do not operate until cause of trouble is determined and corrected.

3. Starting procedure for pumps is as follows:

    a. Prime pump by opening suction valve and closing drains and prepare pump for operation.
    b. Open sealing-liquid supply valves if pump is so fitted.
    c. Start motor.
    d. Open discharge valve slowly.
    e. Observe leakage from stuffing boxes and adjust sealing-liquid valve for proper flow to ensure lubrication of packing. Do not tighten gland immediately but let packing run in before reducing leakage through stuffing boxes.
    f. Check general mechanical operation of pump and motor.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Contractor is responsible for proper disposal of water if large quantities are required.

5. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Fire hoses are for field-acceptance tests only and are not property of Owner.

3.7 DEMONSTRATION

A. Final acceptance test:

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps, drivers, controllers, and pressure-maintenance pumps.

END OF SECTION 213113

SECTION 220000

PLUMBING

PART 1 GENERAL

1.1 WORK INCLUDED

A. Work included in Division 22 Plumbing: Provide all materials, equipment, fabrication, installation and tests as noted in Contract Documents in conformity with applicable codes and authorities having jurisdiction.

B. Related Sections
   1. All work in every Section must also comply with such general conditions of the specifications as are applicable, including, but not limited to
      a. Instructions to Bidders
      b. General Conditions
      c. Special Conditions
      d. Supplementary Conditions
      e. Division 1 General Requirements
   2. Section 01120 LEED® Requirements, provisions of LEED® environmental categories and credits and submittal requirements
   3. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation. See also Coordination Table in Section 230501 Basic Mechanical Materials & Methods.

C. Related Work Specified Elsewhere
   1. Commissioning: See Section 019100 Commissioning
   2. Utilities five feet beyond building line unless noted otherwise: See Division 33 Utilities
   3. Underground de-watering piping: See Division 31 Earthwork
   4. Irrigation piping: See Division 32 Exterior Improvements
   5. Pre-cast concrete planter boxes and site drainage structures: See Division 3 Concrete
   6. Structural steel (except as specified herein): See Division 5 Metals
   7. Miscellaneous lumber and framing work, such as for framing, soffits and support of mechanical materials and equipment: See Division 6 Wood, Plastics, and Composites
   8. Scupper downspout overflow drains: See Division 7 Thermal and Moisture Protection
   9. Painting: See Division 9 Finishes
   10. Accessories including soap dispenser: See Division 10 Specialties

1.2 REFERENCE STANDARDS

A. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid. Such codes or standards shall be considered a part of this Specification as though fully repeated herein.

B. Work shall be performed in accordance with all applicable requirements of the latest edition of all governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not.

C. Requirements of Regulatory Agencies
   1. In accordance with the requirement of Division 1 General Requirements
   2. Nothing in contract documents shall be construed to permit work not conforming to current and applicable laws, ordinances, rules and regulations.
   3. When contract documents exceed requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.
   4. It is not the intent of contract documents to repeat requirements of codes except where necessary for completeness or clarity.
   5. Seismic construction and restraints: In accordance with requirements of Title 17 of California Administrative Code.
   6. Comply with the Safety Orders issued by California Occupational Safety and Health Act, COSHA and any other safety, health or environmental regulations of the State of California and any districts having jurisdictional authority. Where an omission or conflict appears between COSHA requirements and the Drawings and Specifications, COSHA requirements shall take precedence.
   7. Applicable codes as listed below, in addition to others specified in individual sections
      a. CEC – California Electrical Code
      b. CBC – California Building Code
      c. CMC – California Mechanical Code
      d. CPC – California Plumbing Code
      e. City and County Codes and Amendments
      f. California Code of Regulations, including Titles 8, 17, 19, 20, 21, 22 and the California Building Standards Code Part 2, Basic Building Regulations.

D. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in Division 22 Plumbing, in addition to other standards which may be specified in individual sections.

E. All base material shall meet ASTM and ANSI standards

F. All Pressure Vessels, Relief Valves, Safety Relief Valves and Safety Valves: Comply with standards, ASME stamped

G. All Electrical Devices and Wiring
   1. Conform to standards of CEC/NEC
   2. All devices UL or ETL listed and identified

H. Guidelines and Standards: The latest edition of guidelines and standards published by the following groups will govern the Mechanical Systems and associated support system design. The systems shall be designed to meet or exceed these guidelines and standards.

AGA	American Gas Association
AMCA	Air Movement and Control Association, Inc.
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWS	American Welding Society
COSHA	California Occupational Safety and Health Act
ETL	Intertek Semko (Formerly Electrical Testing Laboratories)
GISO	General Industry Safety Orders
HI	Hydraulic Institute
IEEE	Institute of Electrical and Electronic Engineers
NBS	National Bureau of Standards

NEBB	National Environmental Balancing Bureau
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
OSHPD	Office of Statewide Health Planning and Development
PDI	Plumbing and Drainage Institute
SFA	California State and Local Fire Marshall
UL	Underwriters' Laboratories, Inc.

1.3 QUALITY ASSURANCE

A. Supply all equipment and accessories in compliance with the applicable standards listed in Paragraph 1.2 and with all applicable national, state and local codes.

B. All equipment and accessories shall be new and the product of a manufacturer regularly engaged in its manufacture.

C. All items of a given type shall be the products of same manufacturer.

D. All work in Division 22 Plumbing shall be commissioned. See Section 019100 Commissioning and Section 220800 Plumbing Commissioning.

1.4 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner's Representative.

B. Submit drawings, product data, samples and certificates of compliance required as hereinafter specified.
   1. See also Division 1 Shop Drawings, Product Data and Samples. Conditions in this Section take precedence over conditions in above referenced Section.
   2. Provide submittals promptly in accordance with schedule and in such sequence as to cause no delay in work or in work of any other division.
   3. It is not required (nor desired) for all products to be submitted concurrently. Rather, submittals may be staggered based on schedule and required equipment release dates.
   4. Allow 15-working days for review, unless the Owner's Representative agrees to accelerated schedule.
   5. For substitutions, list any features or characteristics that are not strictly in compliance with specifications. If none are listed with the submittal, Contractor is guaranteeing that substituted product is functionally equivalent to the specified product in accordance with Paragraph 1.6.
   6. Submittal reviews by the Owner's Representative are intended to assist the Contractor in complying with the design intent and requirements of the drawings and specifications. Reviews do not relieve the Contractor from compliance with these requirements, and comments or lack thereof do not constitute approval of changes in these requirements.

C. Submission and Resubmission Procedure
   1. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as "SUBMITTAL 220000-01"
   2. Each resubmittal shall have the original unique serial number plus unique revision number such as "SUBMITTAL 220000-01 REVISION 1"

3. Submit in format specified below. Submissions made in the wrong format will be returned without action.
    a. Product Submittals: One copy in word-searchable electronic format per Paragraph 1.5A.4.c.
    b. Shop Drawings:
        1) One copy in electronic format .dwg, .dwf, .pdf or .tif
        2) Two and only two copies on paper; any additional copies will not be returned
    c. Samples: As indicated in each specification section
4. Owner's Representative will return a memo or mark-up of submittal with comments and corrections noted where required.
5. Make corrections
    a. Revise initial submittal to resolve review comments and corrections.
    b. Indicate any changes that have been made other than those requested.
    c. Clearly identify resubmittal by original submittal number and revision number.
6. Resubmit revised submittals until no exceptions are taken.
7. Once submittals are accepted and stamped with no exceptions taken, provide
    a. Complete submittal of all accepted products in a single electronic file for each specification section.
    b. Photocopies for coordination with other trades, if and as required by the General Contractor or Owner's Representative.

D. Product Data Submittals
1. Contents
    a. Manufacturer's name and model number
    b. All information required to completely describe materials and equipment and to indicate compliance with drawings and specifications, including, but not limited to:
        1) Schedule when more than one of each item is covered by submittal
        2) Physical data, as applicable
            a) Dimensions
            b) Weight
            c) Finishes and colors
            d) Dimensional shop drawings
        3) Performance data, as applicable
            a) Rated capacities
            b) Performance curve
            c) Operating temperature and pressure
        4) Flow and wiring diagrams as applicable
        5) Description of system operation
    c. All other pertinent information requested in individual sections
2. Format
    a. See Division 1 Shop Drawings, Product Data and Samples
    b. Identify clearly if submittal is substitution: Refer to Paragraph 1.6
    c. Reference specification Division, Section, Title, Paragraph and Page number or drawing number as applicable
    d. Use same nomenclature, legend, symbols and abbreviations on submittal material as used in contract documents

E. Layout Shop Drawings. See Section 230501 Basic Mechanical Materials and Methods.

F. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table. "R" means required.

Item				
Drains and cleanouts	R	R		R
Plumbing pipe and fittings	R	R		R

Item				
Plumbing fixtures and trim	R	R		R
Insulation	R	R		
Trap primers	R	R		R
Plumbing valves	R	R		R
Water heating equipment	R	R		R
Water sterilization	R	R		R

1.5 COMPLETION REQUIREMENTS

A. Procedure
1. Until the documents required in this section are submitted and approved, the system will not be considered “accepted”
2. Before requesting acceptance of work, submit one set of Completion Documents for review and approval of Owner’s Representative
3. After review, furnish quantity of sets indicated below to Owner
4. Format
   a. See Paragraph 1.5F for required format of Completion Documents
   b. Paper copies; assemble in chronological order following alpha-numeric system used in specification, in heavy three-ring binder
   c. Where electronic copies are called for in Paragraph 1.5F, comply with the following:
      1) Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf) and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable
      2) For submittals, provide separate file for each type of equipment
      3) Record drawings shall be in AutoCAD version 2000 or later.

B. Operating and Maintenance (O&M) Manual
1. In accordance with requirements of Division 1 Operating and Maintenance and as follows
2. O&M Manual shall include but is not limited to the following
   a. Complete Product Data Submittals per Paragraph 1.4 so that the details of the device are known
   b. Manufacturer's name, model number, service manual, spare-parts list and descriptive literature for all components
   c. Operating instructions
   d. Maintenance and repair requirements
   e. Wiring diagrams
   f. Requirements for special tools, test kits and calibration instructions
   g. Replacement parts list
   h. Name, address and phone number of contractor’s equipment suppliers and service agencies

C. Record Drawings
1. Keep up-to-date during progress of job, one set of reproducible and erasable transparencies of Mechanical Drawings indicating the Record installation. In addition to changes made during course of Work, show following by dimension from readily obtained base lines
   a. Fully illustrate all revisions made by all crafts in course of work
   b. Include all field changes, adjustments, variances, substitutions and deletions, including all Change Orders
   c. Exact location, type and function of concealed valves, dampers, controllers, piping, air vents and piping drains
   d. Exact size, invert elevations and location of underground and under floor piping and ducts

2. Progress drawing set shall be available for inspection by Owner's Representative weekly
3. Update shop drawings and record drawings to reflect revisions and additional data listed above at completion of Project
    a. Original engineering design drawings will be provided to Contactor in electronic format compatible with AutoCAD version 2000 or higher
    b. Both shop and record drawings shall be in format compatible with AutoCAD version 2000 or later

D. Commissioning & Training
1. See Section 220800 Plumbing Commissioning

E. Miscellaneous Certificates
1. Pressure Test documentation/certificates
2. Training/Instruction completion certificates
3. Fire Marshal and Fire Department approvals of system, as required
4. Final inspection certificate signed by governing authorities
5. Warranty period, including start and end period
6. Field test report, including as applicable
    a. Start up documents with date and name of technician
    b. Piping pressure tests
    c. Flex coupled pump alignment verification
    d. Letters from manufacturers certifying their supervision of equipment installation and start-up procedures
    e. Machinery vibration test reports where specified
    f. Certificates of sterilization/chlorination of plumbing systems
    g. Others as specified herein

F. Format of Completion Documents
1. Provide the type and quantity of media listed in table below
2. Optical media shall be readable on Operator Workstation: See Section 250000 Building Automation Systems
3. Where indicated in table, the electronic files shall be stored on the BAS systems' Operator Workstation. See Section 250000 Building Automation Systems

	Document	Paper (binder or bound)	Electronic	
			Read only optical disk	Loaded onto Operator Workstation
1.	O&M Manuals	3	1	1
2.	Record Drawings	2 Full size 2 Half size	1	1
3.	Commissioning Reports	5	1	–
4.	Miscellaneous Certificates	1	–	–
5.	Warranty documents	1	–	–
6.	Training materials	1 per trainee	1	1

1.6 SUBSTITUTIONS AND PRODUCT OPTIONS

A. Contractor's Options
1. For products specified only by functionality and/or reference standard, select product meeting that functionality and/or standard, by any manufacturer.
2. For products specified by manufacturer and model number

a. Where “Or Equal” lists specific alternative manufacturers including specific model numbers, any of these specific products may be selected and will not be considered a substitution.
b. Where “Or Equal” lists specific alternative manufacturers but no specific model numbers
    1) Functionally equivalent products by listed alternative manufacturers may be selected.
    2) Functionally equivalent products by manufacturers not listed may be selected but may be rejected by Owner’s Representative for any reason if there is any question with respect to functional equivalency including unfamiliarity with manufacturer and local representation.
    3) Functional equivalent products to the product specified are those that
        a) Are equal or better in quality, function, capacity, efficiency, serviceability, local support, etc.
        b) Fully meet the product specifications unless otherwise approved by the Owner’s Representative
        c) Meet site and application constraints including but not limited to size, weight, appearance, and clearance requirements.

B. Substitution Requirements
1. Where substitutions are proposed for products indicated in design documents, the Contractor shall take full responsibility for coordinating with others the requirements of the proposed substitution including but not limited to:
    a. Adequate space, including service access space
    b. Power and other electrical connections
    c. Pads or other equipment supports
    d. Control devices and interfaces
2. Include all costs for redesign and other work required by all disciplines affected by a substitution.

1.7 DESCRIPTION OF BID DOCUMENTS

A. Specifications
1. Specifications, in general, describe quality and character of materials and equipment
2. Specifications are of simplified form and include incomplete sentences
3. Words or phrases such as "The Contractor shall," "shall be," "furnish," "provide," "a," "an," "the," and "all" have often been omitted for brevity

B. Drawings
1. Drawings in general are diagrammatic. Intention is to show size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement.
2. Scaled and figured dimensions are approximate and are for estimating purposes only. Indicated dimensions are limiting dimensions where noted. Duct and piping elevations are indicated for initial coordination; final requirements shall be determined by the Contractor after final coordination with other trades.
3. Before proceeding with work check and verify all dimensions in field.
4. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
5. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom and avoid architectural openings, structural members and work of other trades.
6. For exact locations of building elements, refer to dimensional Architectural and Structural drawings.

C. Do not use equipment exceeding dimensions indicated on drawings or equipment or arrangements that reduce required clearances or exceed specified maximum dimensions.

D. If any part of Specifications or Drawings appears unclear or contradictory, apply to Owner's Representative for an interpretation and decision as early as possible.
   1. Do not proceed with work without the decision of the Owner's Representative.

1.8 DEFINITIONS

A. Definitions of term used in Division 22 Plumbing may differ from those given in general and supplementary conditions and take precedence over them.

B. "Provide": to furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.

C. "Supply": to purchase, procure, acquire and deliver complete with related accessories.

D. "Work": labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

E. "Piping": pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.

F. "Wiring": raceway, fittings, wire, boxes and related items.

G. "Concealed": embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.

H. "Exposed": not installed underground or "concealed" as defined above.

I. "Indicated," "shown" or "noted": as indicated, shown or noted on drawings or specifications.

J. "Reviewed," "approved," or "directed": as reviewed, approved, or directed by or to Owner's Representative.

K. "Motor Controllers": starters, variable speed drives, and other devices controlling the operation of motors.

L. "Control or Actuating Devices": automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

1.9 PROJECT CONDITIONS

A. Examine site related work and surfaces before starting work of any Section
   1. In case of conflict, the most stringent takes precedence
   2. For purposes of clarity and legibility, Drawings are essentially diagrammatic to extent that many offsets, bends, unions, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Especially note a number of required duct and pipe offsets to coordinate with structure and not shown. Coordinate dimensioned conditions, including invert elevations, with other trades prior to installation by any trade.
   3. Exact routing of piping, ductwork, etc. shall be governed by structural conditions, obstructions. Not all offsets in ductwork or piping are shown on the Mechanical Drawings. Determine which item to offset or relocate. Maintain required slope in piping. Make use of data in Contract Documents. In addition, Owner's Representative reserves right, at no additional cost to the Owner, to make any reasonable change in location of mechanical items, exposed at ceiling or on walls, to

group them into orderly relationships or increase their utility. Verify Owner's Representative's requirements in this regard prior to rough-in.

4. Take dimensions, location of doors, partitions, similar physical features from Architectural Drawings. Verify at Site under this Division. Consult Architectural Drawings for exact location of outlets to center with Architectural features, panels, etc., at the approximate location shown on mechanical Drawings.
5. Mounting heights of brackets, outlets, etc., as required
6. Report to Owner's Representative, in writing, conditions which will prevent proper provision of this work
7. Beginning work of any Section without reporting unsuitable conditions to Owner's Representative constitutes acceptance of conditions by Contractor
8. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to the Owner

B. Coordination

1. Work out all "tight" conditions involving Work specified under this Division and Work in other Divisions in advance of installation. If necessary, and before Work proceeds in these areas, prepare supplementary Drawings under this Division for review showing all Work in congested area. Provide supplementary Drawings, additional Work necessary to overcome congested conditions, at no additional cost to the Owner.
2. Conflicts: Difference or disputes concerning coordination, interference or extent of Work between sections shall be decided as follows
    a. Install mechanical and electrical systems in the following order of preference (those trades listed below another must reroute to resolve the conflict):
        1) Drain piping required by code to be sloped
        2) Supply air and exhaust air ductwork connected to fans
        3) Electrical conduit 4 inches and larger
        4) Hydronic piping connected to pumps
        5) Domestic water piping
        6) Fire sprinkler piping
        7) Electrical conduit smaller than 4 inches
        8) Sprinkler piping
        9) Transfer ducts and other ductwork not connected to fans
        10) Control system piping and wiring
    b. Continued disputes shall be decided by Contractor and Contractor's decision, if consistent with Contract Document requirements, shall be final.
3. Supervision: Personally or through an authorized and competent representative, constantly supervise the work from beginning to completion and, within reason, keep the same foreman and workmen on the Project throughout the Project duration.
4. Provide templates, information and instructions to other Divisions to properly locate holes and openings to be cut or provided.
5. The drawings govern in matters of quantity, and the specifications govern in matters of quality. In the event of conflict within the drawings involving quantities, or within the specifications involving quantities, or within the specifications involving quality, the greater quantity and higher quality shall apply. Such discrepancies shall be noted and clarified in the Bid. No additional allowances will be made because of errors, ambiguities, or omissions that reasonably should have been discovered during the preparation of the Bid.

C. Equipment Rough-In

1. Rough-in locations shown on Drawings for equipment furnished by the Owner and for equipment furnished under other Divisions are approximate only. Obtain exact rough-in locations from following sources
    a. From Shop Drawings for equipment provided under this contract
    b. From Owner's Representative for Owner furnished-Contractor installed equipment

c. From existing equipment where such equipment is relocated under this Contract

2. Verify mechanical characteristics of equipment before starting rough-in. Where conflict exists between equipment and rough-in shown on Drawings obtain clarification from Owner's Representative and provide as directed by the Owner's Representative at no additional cost to the Owner.
3. Make final connections

1.10 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping
1. Prohibited, except as noted, in
   a. Electric rooms and closets over equipment, as restricted by CEC
   b. Telephone rooms and closets
   c. Elevator machine rooms
   d. Electric switchboard room
2. Prohibited, except as noted, over or within 5 feet of
   a. Transformers
   b. Substations
   c. Switchboards
   d. Motor control centers
   e. Standby power plant
   f. Bus ducts
   g. Electrical panels

1.11 PRODUCT DELIVERY, HANDLING AND STORAGE

A. See Division 1 Product Requirements

B. Deliver equipment in its original package to prevent damage or entrance of foreign matter. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Provide protective coverings during construction.

C. Handle and ship in accordance with manufacturer's recommendations

D. Identify materials and equipment delivered to Site to permit check against approved materials list, reviewed with no exceptions taken Shop Drawings

E. Protect from loss or damage. Replace lost or damaged materials and equipment with new at no additional cost to the Owner

F. Where necessary, ship in crated sections of size to permit passing through available space

1.12 PROJECT MANAGEMENT AND COORDINATION SERVICES

A. See Division 1 Project Coordination

B. Overview: Provide a project manager/engineer for the duration of the Project to coordinate the Division 22 Plumbing work with all other trades. Coordination services, procedures and documentation responsibility shall include, but shall not be limited to the items listed in this section.

C. Review of shop drawings prepared by other subcontractors
   1. Obtain copies of all shop drawings for equipment provided by others that require electrical service connections or interface with Division 22 Plumbing work.
   2. Perform a thorough review of the shop drawings to confirm compliance with the service requirements contained in the Division 22 Plumbing contract documents. Document any discrepancy or deviation as follows:
      a. Prepare memo summarizing the discrepancy
      b. Provide a copy of the specific shop drawing, indicating via cloud, the discrepancy
   3. Prepare and maintain a shop drawing review log indicating the following information
      a. Shop drawing number and brief description of the system/material
      b. Date of your review
      c. Indication if follow-up coordination is required

D. Request for information (RFI)
   1. See Division 1 Request For Information

1.13 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by the Owner's Representative

B. Advise Owner's Representative that work is ready for review at following times:
   1. Prior to backfilling buried work
   2. Prior to concealment of work in walls and above ceilings
   3. When all requirements of Contract have been completed

C. Neither backfill nor conceal work without Owner's Representative's consent.

D. Maintain on job set of Specifications and Drawings for use by Owner's Representative's
   1. Include all change orders.

E. Contractor is responsible for construction methods, sequences and safety precautions

1.14 CUTTING AND PATCHING

A. See Division 1 Cutting, Patching and Matching

1.15 UTILITY CONNECTIONS

A. See Paragraph 1.1C.2

B. Connection to utility company mains

C. Connection to on-site piping mains

D. Payment of service charges

E. Provisions for temporary utilities

F. Provide concrete pads, stainless steel pipe supports, anchors and stainless steel caged enclosures for connections to exterior pressure regulating valve assemblies and exterior backflow preventer assemblies

provided by utility company or provided under this section of work. Installation of pads, supports, anchors and enclosures shall be per the requirements of the authority having jurisdiction or the utility company.

1.16 WARRANTY

A. In accordance with Division 1 Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows

B. Warranty all materials, equipment, apparatus and workmanship to be free of defective materials and faulty workmanship for period of one year from date of filing of Notice of Completion or upon beneficial use, at the direction of the Owner's Representative.

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner's Representative to be defective or faulty

D. This guarantee also applies to services including instructions, adjusting, testing, noise, balancing, etc.

E. Furnish Manufacturers' standard Warranties in excess of one year

PART 2 PRODUCTS

2.1 PLUMBING FIXTURES

A. All fixtures are subject to review and approval by the Architect

B. Vitreous china fixtures shall be twice fired white vitreous china.

C. All plumbing fixtures shall be certified by and comply with the State of California Energy Commission (CEC) water conservation regulations and CalGreen.

D. All fixtures for handicapped personal shall be mounted in accordance with the California Code of Regulations, Title 24, handicapped regulations.

E. Seal up joints between fixtures and wall or floor with white mastic.

F. Provide tubing supplies, traps, pipe flanges and wastes to wall of not less than #17 gauge polished chromium-plated brass. Unless noted otherwise, supplies and traps shall be centered, plumb, and perpendicular to wall for lavatories and sinks.

G. Water Closets (WC-1 and WC-1H): Toto CT708UV(G) (1.0 gpf), or equal, wall mounted, vitreous china water closet, ECOPOWER Ultra High-Efficiency (1.1 gpf) flush valve. Water closet seat shall be Bemis, Church, or equal, white plastic seat with self-sustaining check hinge. Water closets marked WC-1H are for handicapped personnel.
    1. Water Closet Carriers: Adjustable combination wall closet fitting and chair carrier, Watts ISCA Series, Zurn, or equal.

H. Lavatories (LV-1): SloanStone Series Sink model ELGR 8X000 Gradient Style Sink or equal, wall mount per manufacturers recommendations; Toto Model #TEL1A3-D20E series Libella ECOPOWER sensor faucet with ASSE 1070 certified mixing valve at 0.35 gpm, Provide McGuire or equal; grid strainer,

polished chrome cast brass tailpiece, trap, and McGuire hot and cold water supply stop valves. LV-1H units shall be mounted in accordance with ADA accessibility guidelines. Provide floor mounted fixture carrier

I. Lavatories (LV-2): Kohler K-2005 “Kingston”, American Standard, or equal. Wall mounted vitreous china; Toto Model #TEL1A3-D20E series Libella ECOPOWER sensor faucet with ASSE 1070 certified mixing valve at 0.35 gpm, Provide McGuire or equal; grid strainer tailpiece, offset waste, trap, and McGuire hot and cold water supply stop valve. Provide floor mounted fixture carrier. Mount at ADA height.

J. Sink LAC (SK-1): Elkay EHS-18X with splash mount, Goose Neck Faucet with 1.5 gpm aerator or equal: Wall mounted with overall dimensions of 18” left to right; 14” front to back, 18 gauge, type 304 stainless steel with centered drain opening. Provide McGuire strainer, tailpiece, insulated offset waste, supply stop valves and trap. Entire assembly shall be mounted in accordance with ADA accessibility guidelines.

K. Sink Staff Lounge and Library Classroom (SK-2): Elkay LRADQ312255 or equal: Self rimming counter mount with overall dimensions of 31” left to right; 22” front to back, 18 gauge, type 304 stainless steel with full undercoating, off centered drain opening and crumb-cup strainer and tailpiece. Sink shall be complete with Chicago Faucet 1100-GN2AE35-317AB hot and cold water sink faucet with wrist blade handles, gooseneck spout,1.5 gpm aerator, ceramic disc operating cartridges and faucet with polished chrome finish. Provide McGuire crumb cup strainer, tailpiece, insulated offset waste, supply stop valves and trap. Entire assembly shall be mounted in accordance with ADA accessibility guidelines.

1. Provide piping rough-ins and connections to dishwashers, coffee machines, refrigerator ice makers.
2. Provide a fully accessible wall cleanout inside the base cabinet for sink.

1. Provide sinks with InSinkErator Badger 5 Food Waste Disposer, continuous feed, with ½ H.P. motor, galvanized steel grinding elements with two stainless steel 360 degree swivel lugs. Self service wrench

L. Service Sinks (SSK): Florestone, Fiat, or equal, 24”x 24”x10” high, pre-cast terrazzo with acid resisting tiling flanges cast-in, brass drain cast in center with chromium plated removable open grid strainer, and stainless steel caps integrally cast in on exposed ledges. Receptor shall be reinforced throughout. Install cast iron hub & spigot p-trap below floor. Faucet shall be Chicago 897 faucet, polished chrome plated, with wall brace, integral stops, hose spout with pail hook and vacuum breaker. Mount faucet on wall 3’-0” above bottom of receptor.

M. Drinking Fountain (DF): Haws H1119.14, Elkay, or equal, dual height, wall mounted, all 18-gauge type 304 stainless steel with No.4 satin finish, and complete with common single piece back plate, bubblers, automatic stream controls, dual push buttons, traps and screwdriver stops, vandal-proof bottom access plates, wall box, and all necessary mounting accessories and devices. Back plate shall be absolutely true and each shall be secured with concealed fasteners.

2.2 DRAINS AND CLEANOUTS:

A. Zurn, Wade or as noted, or equal

B. Floor Drains, (FD-1): Z415 with 6” diameter adjustable nickel-bronze strainer, with cast iron body, clamping device and double drainage flange. Except for shower drains, provide all other drains with cast iron p-trap with ½” primer tap.

C. Floor Drains, (FD-2): Z415, cast iron body with clamping device, 1/2” trap priming connection, and double drainage flange, with heavy duty tractor strainer, ½” trap primer, 7” diameter strainer. All exposed components shall be nickel-bronze.

D. Floor Sinks, (FSK): cast iron floor sink with acid-resisting porcelain enameled interior, internal dome, nickel bronze frame. Set frame flush with the finished floor. All floor sinks shall be provided with a ½" trap primer connection.
   1. FSK: Zurn 1930, rectangular 8" x 4" x 4" deep, with ½ grate

E. Cleanouts: Z1440A, cast iron body, sealed with raised head bronze threaded plug, shall be complete with cast iron body, raised head bronze threaded plug.

F. Wall Cleanouts (WCO): Z1445-4, smooth chromium-plated bronze access cover and frame. Unit shall be complete with a cleanout assembly and smooth chromium-plated bronze access cover and frame. Provide wall cleanout to serve each urinal

G. Floor Cleanout (FCO): Z1400, floor level cleanout with round top , cast iron body with clamp ring and flange, neoprene seal, bronze threaded plug and scoriated nickel-bronze cover. Heavy duty cleanouts shall be provided in all parking garage levels, loading dock and garage ramp areas.

H. Cleanout to Grade (COTG): Z1400, cast iron floor cleanout with round heavy-duty scoriated cast iron tractor cover.

I. Furnish suitable wrenches for each style of cleanout plug or cap.

J. All floor drains and floor sinks shall be trapped, primed and vented.

K. All floor drains, floor sinks and floor cleanouts in areas with epoxy flooring or a similar float-on finish shall have integral extended flange, same material and drain body to receive the epoxy or similar flooring. Contractor shall confirm locations with the Architect.

2.3 SHOCK ABSORBERS

A. Wade, MIFAB, or equal

B. Provide complete with a line size shut-off valve.

C. Size of units shall be per PDI (Plumbing and Drainage Institute) Standards

2.4 TRAP PRIMERS

A. MIFAB, or equal
   1. 3 psi pressure drop actuated type.
   2. Provide complete with a line size shut-off valve and union.
   3. Trap priming provisions shall be provided for all floor drains.

B. Zurn P6000-TPO, or equal
   1. Flush valve type, complete with 1-1/2" flush tube with trap primer collar, spud coupling and flange for top spud connection. 3/8" x 12" supply tube and fittings, vacuum breaker, vacuum breaker tube and wall nut and wall escutcheon.

2.5 ICE MAKER BOXES (IM) (FOR REFRIGERATORS WITH ICEMAKERS):

A. Guy Gray Mfg. Co. Model BIM875, 18-gauge steel box and cover complete with compression outlet.

B. Refer to Architectural Drawings for locations.

C. Water supply to each box shall include a fully accessible shut-off valve.

2.6 (HB-1, HB-2) HOSE BIBBS

A. HB-1, Wall Hydrants: Zurn Z1320XL Encased Ecolotrol, lead free automatic draining wall hydrant for flush installation. Hydrant features integral backflow preventer with anti-siphoning technology, copper casing, all bronze interior components with ½ turn long-life ceramic disc cartridge, combination ¾" female solder and ¾" male pipe thread inlet connection, and ¾" male hose connection. Hydrant furnished with type 304 stainless steel housing with locking hinged cover stamped "WATER" and includes operating key. Install accessible ball valve in each wall hydrant supply which is not otherwise controlled by other local shut-off valve.

B. HB-2, Hot and Cold Wall Faucet: Zurn Z1348-BFP exposed non-freeze anti-siphon dual hot/cold wall faucet complete with automatic draining hose connection backflow preventer, exterior chrome finish, brass casing, all bronze interior parts, operating rod with spring-loaded compression closure valve, replaceable seat washer, combination ½" female solder inlet and ½" mal IP inlet connections standard, and ¾" male hose connection.

2.7 THERMOSTATIC MIXING VALVES

A. Sinks – Watts or equal; Series LFMMV unit

B. Install inside within base cabinet

2.8 WATER HEATING EQUIPMENT

A. (EWH) Electric Water Heater
   1. A.O. Smith model DRE-80-40.5, State, or equal
   2. Electric tank type water heater rated at 40.5 kW, 480V, 3 ph. Complete with ASME rated drain valve, T and P valve. Water heater shall be certified and listed by the State of California Energy Commission and ASME rated.
   3. Refer to Equipment Schedule on drawings.
   4. Provide a Holdrite 40-S-24-A or equal 24" x 24" galvanized support stand assembly below water heater units. The Contractor shall arrange and pay for a licensed Structural Engineer in the State of California to provide structural calculations for support of the electric water heater .
   5. Provide Holdrite or equal, heater restraints. Provide wall backing to receive restraints and mounting hardware.
   6. Provide a Smitty or equal drain pan. Provide drain piping from pan outlet and terminate to spill over floor sink
   7. The Contractor shall arrange and pay for a licensed Structural Engineer in the State of California to provide structural calculations for seismic restraints of water heater.

B. Hot Water Circulating Pump
   1. As specified on Plumbing Equipment Schedule.
   2. Domestic Hot Water Circulating Pump: Shall be B&G, or acceptable equivalent, lead free, all bronze in-line, with 120V, single phase motor, complete with mechanical seals, resilient mounting, and threaded connections.
   3. Pump shall include adjustable aquastat and time clock.

2.9 PIPE MATERIALS AND JOINING SYSTEMS:

A. Sanitary Waste and Vent Piping Below Grade
   1. Pipe shall be manufactured from virgin rigid PVC (polyvinyl chloride) vinyl compounds with cell class 12454 as identified in ASTM 1784. PVC Schedule 40 pipe shall be Iron Pipe Size (IPS) conforming to ASTM D 1785 and ASTM D 2665. Injection molded PVC DWV fittings shall conform to ASTM D 2665. All pipe and fittings shall be manufactured in the United States. All systems shall utilize a separate waste and vent system. Pipe and fittings shall conform to NSF International Standard 14. Solvent cement joints shall be made in a two-step process with primer conforming to ASTM F 656 and solvent cement conforming to ASDT D 2564. Below grade pipe shall be supported from underside of slab.

B. Sanitary Waste and Vent Piping Above Grade
   1. ASTM A74A and CISPI 301 standard weight cast iron soil pipe and fittings. All piping & fittings shall have a standard rust inhibiting coating and shall carry the CISPI mark.
   2. Couplings
      a. Waste Piping: Husky 2000 or 4000 No-Hub Couplings, or equal, type 304 stainless steel couplings with neoprene gasket.
      b. Vent Piping: Husky Standard No-Hub Couplings, or equal, type 301 stainless steel couplings with neoprene gasket.

C. Rainwater Leader, Storm Drain, and Overflow Drain Piping: Same as for sanitary soil, waste, and vent piping

D. Trap Priming, Hot and Cold Water Piping:
   1. Piping above Slab on Grade: Type “L” copper tubing and wrought copper sweat type fittings per ANSI B16-22, ASTM B 813 and ASTM B 828. Solder shall be lead free.
   2. Piping above Slab on Grade: Type “L” copper tubing and wrought copper sweat type fittings per ANSI B16-22, ASTM B 813 and ASTM B 828. Solder shall be lead free.
   3. Piping below Grade (Main Cold Water Service): Type “K” copper tubing and wrought copper sweat type fittings and brazed joints. Copper tubing and fittings shall be per ANSI B16-22, ASTM B 813 and ASTM B 828. Copper tubing and fittings below grade shall be wrapped within 8 mil thick polyethylene tubing.
   4. Piping below Slab on Grade (Trap Priming): Type “K” copper tubing and wrought copper sweat type fittings and brazed joints. Copper tubing and fittings shall be per ANSI B16-22, ASTM B 813 and ASTM B 828. Copper tubing and fittings below grade shall be wrapped within 8 mil thick polyethylene tubing.

E. Condensate Drain Piping: Type “M” copper tubing and wrought copper sweat type fittings.

F. Relief Valve and Indirect Drain Piping: Type “M” copper tubing and wrought copper sweat type fittings.

G. Piping System Accessories

H. Piping system components shall be selected for maximum design operating pressure based on static head and pressure relief valve setting.

I. Reduced Pressure Backflow Preventer (Main Domestic Cold Water):
   1. Watts Model 375, or equal
   2. Main body and access cover shall be epoxy coated ductile iron (ASTM 536), the seat ring and check valve shall NORYL, the stem shall be stainless steel (ASTM 276) and the seat disc elastomers shall be EPDM. The checks and relief valve accessible for maintenance without removing the device from the line.

J. Reduced Pressure Backflow Preventer (Mechanical Make-up Water):
1. Watts Model 975XL2, or equal
2. Main body and access cover shall be low lead bronze (ASTM B 584), the seat ring and internal polymers shall NORYL and the seat disc elastomers shall be silicon. The first and second checks shall be accessible for maintenance without removing the relief valve from the line.

K. Strainers:
1. Watts LF777, or equal
2. Unleaded bronze "Wye -pattern" body to match piping material
3. Perforated stainless screen, size of perforations to suit service
4. Provide valve with lead free hose bib adapter with cap for all strainers
5. Provide strainers at the inlet to all hot water circulating pumps and pressure reducing valves

L. VALVES
1. Ball Valves
   a. 3 inches and smaller
      1) Copper silicon
      2) 316 SS trim
      3) Two piece body
      4) Standard port
      5) 600 pounds per square inch water on gage (WOG) at 100 degree F, 150 pounds per square inch saturated steam
      6) Equal to Watts
      7) Threaded - LFB6000
      8) Soldered - LFB6001
   b. 4 inches and larger: Not used

M. Check Valves
1. Check Valves, Water Service
   a. 3 inches and smaller
      1) Swing check
      2) 200 psig @ 250 degree F water
      3) Brass disc
      4) Screw-in cap
      5) Soldered ends
      6) Equal to Milwaukee
         a) Soldered - UP968
   b. 4 inches and larger
      1) Swing Check
      2) Class 125 (125 psi steam, 200 psi water)
      3) Regrinding bronze disc
      4) Bolted cap
      5) Flanged body
      6) Equal to Nibco F-918-8 and suitable for potable water service

N. Point of Use Thermostatic Mixing Valves at Domestic Water Faucets
1. Zurn,ZW1070XL or equal, ASSE 1070 listed, minimum flow of 0.35 GPM with check stops and strainers. At SK units shall be installed against back inside wall of cabinet. For lavatories install along wall.

O. Safety Relief Valves
1. Size: ASME Code
2. Similar to Watts No. LF140
3. Lead free

4. Adjustable

P. WATER METERS
1. Domestic Cold Water: Badger Recordall model 450 or equal, 3” size water meter on incoming domestic cold water supply. Meter shall be monitored by the site BAS.
2. Domestic Hot water: Badger E-Series Ultrasonic, 1-1/2” size water meter on hot water supply piping. Meter shall be monitored by the site BAS.

2.10 MISCELLANEOUS

A. Pipe Supports:
1. Cooper B-Line, Superstrut, or equal (Provide type 316 Stainless Steel for below grade installation)
2. Where pipe is insulated, protect insulation at hangers by installing a 22 gauge shield and clamp sized to allow pipe insulation to pass continuously through the hanger.
3. For all hot water piping, provide 360 degree high density calcium silicate insert within shield.

B. Equipment Connections: At a minimum, provide at all equipment connections:
1. Isolation valves and union for each connection
2. Drains with ball valve and hose connection with cap

C. Escutcheons: Provide chromium steel escutcheons at piping penetrations of walls where exposed public view and required for proper appearance. Provide galvanized steel escutcheons at penetrations of masonry walls elsewhere. Escutcheons not generally required at drywall penetrations where not exposed to public view.

D. Sleeves:
1. Provide sleeves where pipes pass through floors above grade, roofs, poured-in-place masonry walls, and exterior walls.
2. Sleeves shall be standard weight steel pipe, except sleeves for concealed piping through floors not in structural members may be 25-gauge galvanized sheet metal.
3. Floor sleeves for piping shall extend from the bottom of the slab to 2-inches above the finished floor.
4. Seal between piping and sleeve with fire-rated caulk at all penetrations of fire-rated partitions and floors.
5. Make sleeves through outside walls watertight. Caulk between uninsulated pipe and sleeve.
6. Size sleeves for insulated pipes to allow full thickness insulation.
7. Coordinate with the requirements of the Structural Engineer regarding any sleeves/penetrations through any structural members. Submit proposed penetrations for Structural Engineer review and approval prior to the Shop Drawing Submittal.

E. Water Proof Sleeve Assembly:
1. Calpico Pipe Linx Model CSL-SSS with 316 grade stainless steel pressure plate.
2. Calpico Wall Sleeve model C-PWS with 2” water stop.

F.

G. Thermometers
1. Weksler, Ashcroft, or equal
2. Stainless steel construction and range of 30 °F to 240 °F

2.11 VIBRATION ISOLATION

A. Manufacturers
   1. Vibration Isolation:
      a. Mason Industries, Inc.
      b. Kinetics Noise Control, Inc.
      c. M.L. Saussé & Co. (Vibrex).
      d. Or equal
   2. Seismic Restraints:
      a. Hangers: Any manufacturer who can verify compliance with SMACNA standards and the California Building Code
      b. Strut: Channel Framing: Any manufacturer who can verify compliance with the CBC standards
      c. Anchors: Drill in, wedge type: Any manufacturer within the ICBO standards approved for seismic
      d. Snubbers: Any manufacturer within the CBC standards

B. Piping Isolation for Noise Control
   1. Isolate water piping from structure with Acousto-Plumb System isolators, holders and guides for 1-inch and smaller.
   2. Isolate waste pipes and water pipes larger than 1-inch with B-Line B3195 Isolator System components
   3. Do not allow the piping, connectors and valves to directly touch the structure, studs, gypsum board, or other pipes

2.12 ANCHORS, INSERTS AND FASTENERS:

A. All anchors and inserts shall be installed according to the CBC standards

B. Do not use any anchor or insert in concrete which does not have a signed structurally engineered design value based on its installed application and one of the following:
   1. ICBO evaluation report
   2. Lab test report verifying compliance

C. All over-head concrete anchors or inserts shall be selected to comply with the ICBO report or CBC table for the anchor or insert

D. Torque testing of anchors shall be allowed to verify compliance of anchor installation. However, torque testing shall not justify usability of anchor. Only load or pull testing shall be allowed to justify usability of anchors. Failure of torque shall constitute failure of anchor.

E. Bolts and nuts:
   1. Bolts and heavy hexagon nuts: ANSI B18.2.1 and ASTM A307 or A576
   2. Bolts, underground: ASTM A325, stainless steel
   3. Expansion anchors: Federal Specification A-A-1922

2.13 INSULATION

A. Manufacturers
   1. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.
   2. Insulation: fiberglass
      a. Owens-Corning Fiberglass Corporation
      b. Manville

c. Certainteed Corporation
d. Knauf
e. Or equal

3. Insulation: Elastomeric Closed Cell:
   a. Armstrong World Industries, Inc.
   b. Rubatex Corp.
   c. Or equal
4. Adhesives
   a. Foster Div. Amchem Products Inc.
   b. Childers Products Company
   c. Epolux Mfg. Corporation
   d. Insul-Coustic/Birma Corporation
   e. Armstrong 520 Adhesive
   f. Or equal
5. Mechanical Fasteners
   a. AGM Industries, Inc.
   b. Miracle Adhesives Corporation

B. General
1. Energy Codes: The current versions of California Title 24 and California Building Code shall govern where requirements for thickness exceeds thickness specified
2. All insulation materials, including jackets, facings, adhesives, coatings, and accessories are to be fire hazard rated and listed by Underwriters' Laboratories, Inc., using Standard UL 723 (ASTM E-84), (NFPA-255), (ASA A2.5-1963)
3. Flamespread: maximum 25
4. Fuel contributed and smoke developed: maximum 50
5. Flameproofing treatments subject to deterioration from moisture or humidity are not acceptable
6. Insulation and accessories shall not provide any nutritional or bodily use to fungi, bacteria, insects, rats, mice, or other vermin, shall not react corrosively with equipment, piping or ductwork, and shall be asbestos free: Duct lining shall meet ASTM C1136 and ASTM C665 for biological growth in insulation

C. Materials
1. Pipe Insulation
   a. Fiberglass:
      1) Molded: one piece, maximum 0.26 K factor at 75 degrees Fahrenheit mean temperature
      2) Equal to Owens-Corning ASJ/SSL-II Pipe Insulation
   b. Flexible, closed cell elastomeric thermal insulation
      1) Insulation ASTM C534
      2) Service rating of 220 degrees Fahrenheit
      3) Density 6.0 pounds per cubic foot
      4) Closed cell foam: Vapor permeability ASTM E96 0.2 perm
      5) Max moisture absorption: 1.0 percent by volume, 10 percent by weight
      6) Molded pipe insulation
         a) Maximum 0.27 K factor at 75 degrees Fahrenheit mean temperature
         b) Maximum water vapor transmission rating of 0.17 perm-inches
2. Jackets
   a. Factory Applied Vapor Barrier All Service Jacket (ASJ)
      1) ASTM C921, White kraft paper bonded to aluminum foil and reinforced with glass fiber yarn
      2) Moisture Vapor Transmission: ASTM E96; 0.02 perm inches
      3) Secure with self-sealing longitudinal laps and butt strips
      4) Secure vapor barrier mastic

5) Tie Wire: minimum 16 gauge copper clad annealed steel wire with twisted ends on maximum 12 inch centers
6) Vapor Barrier Lap Adhesive: Compatible with insulation

b. Aluminum Jacket: ASTM B209:
1) Use for weatherproof jacket
2) Thickness: 0.016 inch sheet
3) Finish: Embossed
4) Joining: Longitudinal slip joints and 2 inch laps
5) Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner
6) Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel

c. Preformed PVC
1) Polyvinylchloride covers similar to Manville "Zeston."
2) Color: white

3. Preformed Pipe Fitting Covers:
a. Aluminum
1) Factory fabricated formed covers
2) Equal to General Aluminum Supply Corp. GASCO
3) Exposed insulation: Insulation exposed to weather shall be protected by a smooth or corrugated aluminum jacket or colored plastic jacket approved for outdoor installation, minimum 0.016 inch thick, secured 3" on center, overlapped at joints and sealed watertight.

2.14 SEISMIC RESTRAINTS

A. General:
1. Capable of safely accepting indicated external forces without failure
2. Maintain equipment and piping in a captive position
3. Seismic design Criteria:
4. Z =0.40
5. Ip = 1.00
a. Soil Profile Type plus the value for Na (in lieu of a value for Ca) as required for Section 1632 of CBC calculation of seismic design force Fp
6. Provide seismic restraints to meet the more stringent requirements of the CBC or the local building code.
7. Restraints shall not short-circuit vibration isolation systems under normal operation.
8. Design and provide restraints to prevent permanent displacement in any direction caused by lateral motion, overturning, or uplift of Plumbing equipment, and piping. Restraints shall meet requirements of the CBC.

B. Published specifications standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this section:
1. "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems"
a. Published by SMACNA Approved by the State of California
2. CBC – California Building Code
3. CPC - California Plumbing Code

C. Seismic load calculations for piping:
1. Calculations required for supports and bracing for situations not covered by referenced "Guidelines"
2. Include horizontal and vertical reaction loads at connections to building structures for all seismic restraints, including those covered by referenced "Guidelines." Coordinate reaction loads and attachment details with structural engineer for building.

3. Calculations made and signed by registered structural engineer knowledgeable in seismic design:
    a. Hired under this Section of work
    b. Cost of calculations borne under this Section
4. Bracing system: One of the following methods as most applicable for each brace:
    a. Material used, except for pipes, shall be structural steel with ASTM A36. Steel pipes shall conform to ASTM A501
    b. Complete system of factory fabricated components
    c. Complete system of job fabricated components
    d. Miscellaneous metal structural shapes

2.15 BACKFLOW PREVENTERS

A. Watts LF009, Zurn Model 375, or equal, lead free reduced pressure device

B. Each unit shall be complete with upstream lead free strainer, check valves, relief valve, ball valves, and test cocks. Furnish and install air gap drain funnel at each reduced pressure device, connect drain piping full size, and terminate over drain provisions as noted on plans.

C. All units shall be listed on the list of approved devices.

D. Contractor shall arrange and pay for device certification per the Authority Having Jurisdiction.

PART 3 EXECUTION

3.1 PROTECTION OF WORK DURING CONSTRUCTION

A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.

B. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage and deterioration during construction. Cover motors and other moving machinery to protect from dirt and water during construction.

C. Material, Equipment or Apparatus:
1. Material, equipment or apparatus damaged because of improper storage or protection will be rejected.
2. Remove damaged material, equipment or apparatus from site and provide new, duplicate, material, equipment or apparatus in replacement of that rejected.
3. Porous materials, such as pipe insulation, shall be protected from weather. If such material becomes wet during construction, it shall be removed and replaced at no cost to Owner; drying is not sufficient due to possible microbial contamination.

3.2 INSTALLATION AND WORKMANSHIP

A. All equipment and material shall be installed in a neat and workmanlike manner.

B. Repair all damaged or temporarily removed walls, roofs, roofing, equipment, etc.

C. Follow manufacturer’s installation instructions and recommendations.

D. All equipment must be anchored to the building. All hung equipment shall incorporate vibration isolation.

3.3 PIPING

A. Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leak resistant piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes where indicated by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance.

B. Wherever possible, piping shall be run in beam bays before offsetting to below a beam.

C. Verify all invert elevations and pitched lines before starting work.

D. Coordinate all pipe runs below structural slab at first floor with the Structural Engineer. Offset piping over top of grade beams/footings; vertical penetrations of structural foundation members is not permissible.

E. Provide insulating couplings or dielectric unions at all connections of ferrous piping to non-ferrous piping.

3.4 VALVES

A. For valves in multiple parallel runs of piping, provide 4” clearance between valve handle and adjacent pipe, or insulation. Install valve handles in horizontal position between pipes. Do not install valve handles on top of pipe.

B. Install valves in accordance with manufacturer’s written installation instructions

C. Provide valves as shown on drawings

D. Provide all valves (except control valves), strainers, and check valves of same size as the pipes in which they are installed unless otherwise indicated

E. Pressure rating of valves same as piping in which installed

F. Install valves with stems upright or horizontal, not inverted

G. Install valves with cast directional arrows in direction of flow

H. Support line valves at the valve in addition to regularly spaced pipe supports shown and specified

I. Check valves:
   1. Provide silent check valves at discharge of pumps. Install swing checks and gravity closing lift checks in horizontal position.

J. Provide blow-down ball valves and hose adaptors at strainers, air separators, tanks, pipe traps, equipment drains, etc. of same size as strainer blow-off connection

K. Provide drain valves at main shut-off valves, low points of piping and apparatus

L. Locate wheel handles to clear obstructions with hand

M. Install valves only in accessible locations

N. Wherever possible, install valves accessible from floor level. Provide guided chain operators on valves over 7 feet above floor in equipment areas. Extend chains to within 6 feet 6 inches of floor.

O. Locate equipment shut-off valves to be accessible without climbing over equipment

P. Provide operating handles for all valves and cocks without integral operators, unless otherwise noted. Provide adequate clearance for easy operation

Q. Provide open-ended line valves with plugs or blind flanges

3.5 PIPE INSULATION SCHEDULE

A. Insulation Application Types
1. Type P-2:
   a. Molded Fiberglass
   b. All-service jacket
   c. Provide calcium silicate inserts for all pipe sizes
2. Type P-3: Flexible elastomeric insulation

B. Application Schedule

Service	Type	Size	Thickness
Domestic Hot Water (All piping from water heaters to each point of use)	P-2	All	Per Title 24 for circulated systems minimum.
Sanitary waste piping serving air-gap assemblies (including underside of drain bodies) within 10 feet of receiving condensate or indirect waste from ice makers	P-3	All	1/2 inch
Condensate drains	P-3	All	1/2 inch
Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities	P-3	All	1/2 inch

C. Non-insulated piping and equipment
1. Vent, overflow, drain and relief, except as noted otherwise

3.6 PIPE INSULATION INSTALLATION

A. Install materials in accordance with manufacturer's instructions

B. Coordinate with work of other trades

C. Deliver material to job site in original non-broken factory packaging, labeled with manufacturer’s density and thickness

D. Install insulation where it cannot become wet. If insulation becomes wet, remove and dispose of properly and replace with new, dry insulation. Wetted insulation is not acceptable. Ensure insulation is dry before and during installation.

E. Insulate all piping, valves, fittings, flanges and accessories

F. Provide calcium silicate inserts for all pipe sizes and all types of supports

G. Insulate fittings, joints and valves with insulation of same material and thickness as adjoining pipe. Use pre-molded fiberglass fitting covers or radial mitered segments of pipe insulation. For strainers, expansion joints, fittings and accessories requiring servicing or inspection insulation shall be removable and replaceable without damage. Enclose within two-piece no. 15 gauge aluminum covers fastened with cadmium-plated bolts and nuts.

H. Insulate flanges with insulation sleeve of same material as pipe insulation to cover flange and overlap insulation on adjacent piping

I. Continue insulation through walls, sleeves, pipe hangers and other pipe penetrations

J. Finish insulation at supports, protrusions and interruptions. No hangers or supports shall be embedded in insulation.

K. Elastomeric Tubing
   1. Provide insulation
   2. Butt edges neatly. Seal longitudinal and transverse joints with adhesive to maintain minimum vapor permeance. Adhesive shall be selected and applied in accordance with insulation manufacturer’s recommendations.
   3. Apply additional jacket as specified

L. Perform work at ambient and equipment temperatures as recommended by adhesive manufacture

M. Protection: Protect against dirt, water, chemical, or mechanical damage before, during, and after installation. Repair or replace damaged insulation at no additional cost

3.7 VIBRATION ISOLATION

A. Installation:
   1. Install isolators and seismic restraints in accordance with manufacturer's written instructions
   2. Make no rigid connections between equipment and building structure that degrade noise and vibration isolation system herein specified:
      a. Electrical conduit connections to isolated equipment shall be flexible liquid tight conduit of sufficient length to incorporate a right angle bend, an offset of not less than 8 inches or a loop to allow free motion of isolated equipment
      b. The Plumbing Sub-contractor shall not install any equipment, piping or conduit which makes rigid contact with the "building" unless permitted in this Specification. Building includes, but is not limited to, slabs, beams, columns, studs and walls
      c. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.

B. Piping Isolation:
   1. Isolate water piping from structure with Acousto-Plumb System isolators, holders and guides for 1-inch and smaller.
   2. Isolate waste, rainwater leader, pipes and water pipes larger than 1-inch with Stoneman Trisolator System components
   3. Wall and Floor Penetrations: Do not allow the piping, connectors and valves to directly touch the structure, studs, gypsum board, or other pipes All piping to be isolated shall freely pass through walls and floors without rigid contacts or connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain 0.75 inches to 1.25 inches clearance around the pipe or duct outside surfaces:

3.8 CLEANING

A. During construction:
   1. Keep openings in piping closed to prevent entrance of foreign matter.
   2. Clean pipe, fittings and valves internally.

B. Clean plumbing fixtures with soap and water. Remove marks and labels. Clean and polish chrome. Remove paint, concrete, plaster and other foreign materials.

C. Clean all drains, and traps, of dirt and debris.

D. Remove shipping paper from cleanout covers and drain strainers and polish.

E. Remove and clean out all dirt and debris from pipe spaces, including all wire, and blocking.

F. All equipment and materials furnished by this Section shall be completely dust and paint free, clean and rust free and freshly painted or polished when the final inspection is made.

G. Thoroughly clean and flush interior and exterior of all piping systems (wet systems, and drainage systems) of any nature of all pipe contaminates such as cuttings, fillings, grease, solder, flux and welding residue.

3.9 STERILIZATION

A. Aquatect. or equal

B. At the completion of testing and adjusting, and before domestic water systems are put into use, they shall be sterilized. Perform the entire disinfection procedure under the supervision of the Authority Having Jurisdiction. Until sterilization of the domestic water system has been made, all water outlets shall have signs posted at their locations stating the water system has not been sterilized and shall not be used for human consumption. The Plumbing Contractor shall furnish and install all valves, outlets, and devices required by the sterilization sub-contractor to complete the sterilization work.

3.10 EXCAVATING, TRENCHING, AND BACKFILLING

A. Perform all excavating, trenching, removal of surplus material, and backfilling required for installation of material and equipment under this Section. Provide and maintain dewatering pumps as required. Any rock excavation and disposal shall be included in Base Bid price.

B. Minimum bury depths, safety and installation requirements shall concur with the Authority Having Jurisdiction.

3.11 EQUIPMENT AND PIPING IDENTIFICATION

A. Equipment:
1. All plumbing equipment shall be identified by nameplates securely fastened in a clearly visible location to the equipment housing or frame. Nameplates shall include the equipment design plan mark and brief description of the area or system served, such as: "Water Softener Building A". Nameplates shall be 2-1/2" x 3/4" minimum, either 1/16" thick Bakelite with engraved white core letters and beveled edge, or aluminum with black enameled background and etched or engraved natural aluminum lettering
2. Manufacturer's nameplate shall be clean and legible and installed in a clearly visible location.

B. Piping:
1. Identify piping with symbol identification, direction of flow arrows and specific pressure zones, complying with ANSI A 13.1 color standards.
2. Identify piping at approximately 25' centers where unconcealed. Concealed piping above inaccessible ceilings shall be identified at each access panel. Concealed piping above accessible ceilings shall be identified within 10 feet of each wall penetration (both sides of walls).
3. Where capped piping is provided for future connections, provide legible and durable metal tags indicating symbol identification.
4. Printed labels with colored background and attaching strap: Seton, W. Brady, or equal.
5. Apply in accordance with manufacturer’s instructions

C. Buried Utility Warning and Identification Tape
1. Seton, Brady, or equal
2. Polyethylene plastic tape manufactured specifically for warning and identification of buried pipe lines. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill material.
3. Install tape 12” above top of pipe during backfilling of trench.

3.12 LEAKAGE TESTING

A. Before conducting tests, valve-off or disconnect any equipment and apparatus which may be damaged by the test pressures higher than normal working pressures. All testing shall be witnessed by the Authority Having Jurisdiction.

B. Sanitary Soil, Waste, and Vent Piping: Hydrostatically test and prove tight, to provide a minimum 10 foot head of water, and in accordance with the governing plumbing code.

C. Domestic Hot and Cold Water Piping: Test and prove tight under 150 PSI hydrostatic pressure.

D. Trap Primer Piping: Test and prove tight under 50 PSI hydrostatic pressure.

3.13 TESTING AND ADJUSTING

A. Adjust all faucets and outlets.

B. Demonstrate correct operation of all water heating equipment

C. Adjust temperatures of water heating equipment.

D. Demonstrate correct operation of thermostatic mixing valves

E. Demonstrate correct operation of trap priming devices.

F. Assist in the testing and adjusting of equipment furnished and installed under other Divisions, but served and connected under this section

END OF SECTION

SECTION 230501

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 SUMMARY

A. Work included: Materials, equipment, fabrication, installation, starting, testing and commissioning in conformance with applicable codes and authorities having jurisdiction for Mechanical Work covered by all sections within this Division including, but not limited to
   1. Heating, ventilating and air conditioning systems and equipment

B. Related Sections
   1. All work in every Section must also comply with such general conditions of the specifications as are applicable, including, but not limited to
      a. Instructions to Bidders
      b. General Conditions
      c. Special Conditions
      d. Supplementary Conditions
      e. Division 1 General Requirements
   2. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation. This section is provided to assist Contractor in coordination of work scope but shall not be construed to limit Contractor's scope of work encompassed by the contract documents.
   3. Coordination with other Trades: The following table is intended to assist the Contractors in coordinating the scope of work between Division 23 HVAC (indicated as 23 in table), Division 25 Building Automation Systems (indicated as 25), and other Divisions as indicated. However, the General Contractor is ultimately responsible for coordination among his subcontractors regardless of what is listed in this Section.

INTERFACE / RESPONSIBILITY MATRIX

System	Division under which the following is specified				Remarks
	Equipment	Installation	Power wiring (remark 1)	Control & interlock wiring (remark 1)	
A. FIRE SPRINKLER SYSTEM					
1. Flow switches	21	21	26	26	
2. Valve monitors	21	21	26	26	
3. Post indicating valves	21	21	26	26	
B. FIRE & LIFE SAFETY SYSTEMS					
1. Fire alarm controls and UUKL atrium smoke controls	26	26	26	26	
2. Duct mounted & in-duct mounted smoke detectors	26	23	26	26	
3. Other smoke detectors	26	26	26	26	

INTERFACE / RESPONSIBILITY MATRIX					
System	Division under which the following is specified				Remarks
	Equipment	Installation	Power wiring (remark 1)	Control & interlock wiring (remark 1)	
4. Smoke control interlocks to HVAC fans	26	26	26	26	2
5. Smoke dampers with electric actuators	23	23	26	26	
6. Smoke damper end switches	23	23	26	26	
C. MECHANICAL EQUIPMENT					
1. Variable speed drives, field mounted	23	26	26	25 /26	3, 7
2. Motors, 3 phase	23	23	26	–	
3. Motor starters, 3 phase	26	26	26	25 /26	**Error! Reference source not found.**, 7
4. Motors, 1 phase	23	23	26	26	5, 6, 7
5. Other powered equipment	23	23	26	25	
6. Disconnects/circuit breakers	26/ 23	26/ 23	26	– /26	8, 9
D. BUILDING AUTOMATION SYSTEM (BAS)					
1. Central control workstations & servers	25	25	26	25	
2. Control system network backbone	25	25	25	25	
3. Line voltage control devices to 120V motors	25	26	26	26	6
4. Window switches	25	25	–	25	
5. Control panels	25	25	26	25	10
6. Control devices	25	25	25	25	
E. ELECTRICAL SYSTEMS					
1. Lighting Control BACnet gateway	26	26	26	25	11
2. Lighting relay panels and low voltage switches	26	26	26	26	
3. Lighting occupancy sensors	26	26	26	26	
4. Daylighting sensors and controls	26	26	26	26	
5. Power monitoring sensors and gateway	26	26	26	26/25	12
F. EMERGENCY POWER SUPPORT SYSTEMS					
1. Muffler	26	26	-	-	
2. Exhaust piping	26	26	-	-	
3. Radiator cooling	26	26	-	-	
4. Generator monitoring and alarm points	26	26	-	25	13
5. Generator fuel system	26	26	26	–	
G. IRRIGATION SYSTEM					
1. Controllers	32	32	26	32	
2. Control valves	32	32	32	32	
3. Flow meters	32	32	32	32	
H. PLUMBING SYSTEMS					
1. Condensate drains including traps, primers	22	22	–	–	14
2. Condensate pumps	–	–	–	–	

INTERFACE / RESPONSIBILITY MATRIX					
System	Division under which the following is specified				Remarks
	Equipment	Installation	Power wiring (remark 1)	Control & interlock wiring (remark 1)	
3. Make-up water to hot/chilled/condenser water including backflow prevention	22	22	–	–	15
4. Water flow meters	25	22	25	25	
5. Recirculation pumps	22	22	26	25	
6. Pipe gauges, thermometers, test plugs	22	22	–	–	
7. Self-powered valves, pressure relief valves, liquid level controllers, etc.	22	22	–	–	
8. Sensor wells, meters and other pipe-mounted control devices	25	22	25	25	
I. HVAC HYDRONIC SYSTEMS					
1. Pipe gauges, thermometers, test plugs	23	23	–	–	
2. Self-powered valves, pressure relief valves, liquid level controllers, etc.	23	23	–	–	
3. Automatic isolation and control valves	25	23	25	25	
4. Sensor wells, meters and other pipe-mounted control devices	25	23	25	25	
J. HVAC SHEET METAL					
1. Duct mounted sensors	25	23	25	25	
2. Filter gauges	25	25	–	–	
3. Control dampers	23	23	–	–	16
4. Control damper actuators	25	25	25	25	16
K. HVAC TERMINAL BOXES					
1. Terminal box control transformer panel	25	25	26	25	10, 17
2. Terminal box with damper	23	23	–	–	
3. Digital controller and damper actuator	25	25	25	25	
4. Air-flow measurement pickup	23	23	–	–	
5. Air-flow measurement transducer and piping	25	25	25	25	
6. Wall sensor module	25	25	25	25	
L. MISCELLANEOUS					
1. Plumbing utilities 5 feet beyond building interior wall line	33	33	–	–	
2. CHW and HW utilities outside building interior wall line	33	33	–	–	
3. Roofing, including cant strips and counterflashing at the sides of roof curbs	7	7	–	–	
4. Thermal and acoustical insulation in and on partitions and ceilings	7	7	–	–	
5. Undercutting of doors and door louvers	8	8			
6. Louvers	8	8	–	–	

INTERFACE / RESPONSIBILITY MATRIX					
System	Division under which the following is specified				Remarks
	Equipment	Installation	Power wiring (remark 1)	Control & interlock wiring (remark 1)	
7. Concrete housekeeping pads, piers, pedestals and inertia base fill etc. for equipment.	3	3	–	–	18
8. Equipment, ductwork, and piping steel supports and frames	23	23	–	–	
9. Grates and railings protecting mechanical shaft and other floor openings	5	5	–	–	
10. Curbs at rooftop units, fans, duct/vent penetrations, and piping penetrations	23	23	–	–	19
11. Painting	9/23	9/23	–	–	20
12. Coring or cutting wall and floor openings for ductwork and piping	23	23	–	–	
13. Fire-stopping and acoustic caulking around pipe and duct penetrations in floors and walls	23	23	–	–	
14. Fire rated enclosures where shown around ducts	9	9			
15. Framing of walls and ceilings to accept air outlets, fire dampers, etc.	9	9	–	–	21
16. Ceiling and wall access doors and panels	8	8	–	–	22

NUMBERED REMARKS:

1. Wiring includes raceway, fittings, wire, boxes and related items, all voltages.
2. Wiring and controls to start and stop fans based on smoke detector status and smoke control logic specified under Division 26 Electrical.
3. Where drive is used for CBC 909 atrium life safety system fan, input to drive to force drive to preset speed specified under Division 23 HVAC; wiring to life safety system specified under Division 26 Electrical.
4. Integral starter control devices such as HOA switches, 120V control transformers specified under Division 26 Electrical.
5. Single phase 120V motors with integral motor overload protection specified under Division 23 HVAC.
6. Line voltage control device such as thermostat or switch specified under Division 25 BAS; wiring and conduit between control device and motor specified under Division 26 Electrical.
7. Fire and life safety control systems, status devices (such as fan status switches and voltage-available relays), start/stop relays and associated wiring and conduit specified under Division 26 Electrical. Identification of mechanical equipment termination contact locations by Division 23 HVAC.
8. Disconnect status where required to be monitored for CBC 909 atrium smoke control systems specified under Division 26 Electrical.
9. Disconnects or circuit breakers are specified under Division 23 HVAC where specifically called for in equipment schedules or specifications to be factory installed with equipment. Otherwise all disconnects are specified under Division 26 Electrical.
10. 120V power to BAS control panels is specified under Division 26 for the panels shown on Drawings. Power to all other control panels that may be required is specified under Division 25 BAS, coordinated with Division 26 contractor for available circuits.
11. Lighting control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across lighting control points to the BAS.

INTERFACE / RESPONSIBILITY MATRIX					
System	Division under which the following is specified				Remarks
	Equipment	Installation	Power wiring (remark 1)	Control & interlock wiring (remark 1)	
12. Power measuring sensors, installation and wiring to a single central controller with BACnet/IP interface specified under Division 26 Electrical. BACnet/IP gateway and network connection from gateway to BAS specified under Division 25 BAS. Power monitoring control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across power monitoring control points to the BAS. 13. Generator monitoring sensors and central controller with Modbus gateway specified under Division 26 Electrical. Gateway and network connection from gateway to BAS specified under Division 25 BAS. Generator vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across monitoring control points to the BAS. 14. Condensate piping from condensate pans to the sewer system including trap and final connections is specified under Division 22 Plumbing. Piping from auxiliary drain pans where provided at fan-coils is specified under Division 23 HVAC. 15. Domestic make-up water, including shut-off valve, backflow prevention, rough-in and final connection to hot water, chilled water, and any other HVAC systems requiring make-up water is specified under Division 22 Plumbing. 16. Duct access doors required for access to control devices where required specified under Division 23 HVAC. 17. Control transformers for terminal boxes shall be centralized in control panels specified under Division 25 BAS. 18. Shop drawings showing dimensions of all curbs, bases, etc. specified under Division 23 HVAC. 19. Shims to level curb specified under Division 6. Curb insulation specified under Division 23 HVAC. 20. Painting of exposed piping, HVAC equipment, etc. per Paragraph 3.7 specified under Division 23 HVAC. All other painting specified under Division 9. 21. Additional T-bar or spline and cut ceiling tile as required to accept air outlets is specified under Division 9. 22. Dimensioning of access doors to mechanical equipment and coordination with Architect and Division 8 specified under Division 23.					

1.2 REFERENCE STANDARDS

A. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid. Such codes or standards shall be considered a part of this Specification as though fully repeated herein.

B. Work shall be performed in accordance with all applicable requirements of the latest edition of all governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not.

C. Requirements of Regulatory Agencies
   1. In accordance with the requirement of Division 1 General Requirements
   2. Nothing in contract documents shall be construed to permit work not conforming to current and applicable laws, ordinances, rules and regulations.

3. When contract documents exceed requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.
4. It is not the intent of contract documents to repeat requirements of codes except where necessary for completeness or clarity.
5. Seismic construction and restraints: In accordance with requirements of Title 17 of California Administrative Code.
6. Comply with the Safety Orders issued by California Occupational Safety and Health Act, COSHA and any other safety, health or environmental regulations of the State of California and any districts having jurisdictional authority. Where an omission or conflict appears between COSHA requirements and the Drawings and Specifications, COSHA requirements shall take precedence.
7. Applicable codes as listed below, in addition to others specified in individual sections
    a. CEC – California Electrical Code
    b. CBC – California Building Code
    c. CMC – California Mechanical Code
    d. CPC – California Plumbing Code
    e. City and County Codes and Amendments
    f. California Code of Regulations, including Titles 8, 17, 19, 20, 21, 22 and the California Building Standards Code Part 2, Basic Building Regulations.

D. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in Division 23 HVAC, in addition to other standards which may be specified in individual sections.

E. All base material shall meet ASTM and ANSI standards

F. All Pressure Vessels, Relief Valves, Safety Relief Valves and Safety Valves: Comply with standards, ASME stamped

G. All Electrical Devices and Wiring
    1. Conform to standards of CEC/NEC
    2. All devices UL or ETL listed and identified

H. Guidelines and Standards: The latest edition of guidelines and standards published by the following groups will govern the Mechanical Systems and associated support system design. The systems shall be designed to meet or exceed these guidelines and standards.

AABC	Associated Air Balance Council
ADC	Air Diffuser Balance Council
AMCA	Air Movement and Control Association, Inc.
ANSI	American National Standards Institute
AHRI	Air Conditioning, Heating, and Refrigeration Institute
ASC	Adhesive and Sealant Council
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWS	American Welding Society
COSHA	California Occupational Safety and Health Act
ETL	Intertek Semko (Formerly Electrical Testing Laboratories)
GISO	General Industry Safety Orders
HI	Hydraulic Institute
IEEE	Institute of Electrical and Electronic Engineers
NBS	National Bureau of Standards
NEBB	National Environmental Balancing Bureau

NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
OSHPD	Office of Statewide Health Planning and Development
SFA	California State and Local Fire Marshall
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.
UL	Underwriters' Laboratories, Inc.

1.3 QUALITY ASSURANCE

A. Supply all equipment and accessories in compliance with the applicable standards listed in Paragraph 1.2 and with all applicable national, state and local codes.

B. All equipment and accessories shall be new and the product of a manufacturer regularly engaged in its manufacture.

C. All items of a given type shall be the products of same manufacturer.

D. All work in Division 23 HVAC shall be commissioned. See Section 019100 Commissioning and Section 230800 Mechanical Commissioning.

1.4 DOCUMENT FORMAT

A. This section applies to all documents specified to be provided by Division 23 specifications except where specifically indicated otherwise.

B. Electronic copies
   1. Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf) and HTML. Scanned paper documents not acceptable even if converted to text with OCR.
   2. For Submittals and O&M Manuals, provide separate file for each specification section or provide one file with hyperlinked tabs to each system.
   3. For Test & Balance report, provide separate files for each air handling system, hydronic system, primary equipment, etc. or provide one file with hyperlinked tabs to each system.
   4. Record drawings shall be in original format per Paragraph 1.6C.3.

C. Paper copies
   1. Only provide where specifically required. In general, only electronic copies are required.
   2. Assemble in chronological order following alpha-numeric system used in specification, in heavy three-ring binder.

1.5 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner’s Representative.

B. Submit drawings, product data, samples and certificates of compliance required as hereinafter specified.
   1. See also Division 1 Shop Drawings, Product Data and Samples. Conditions in this Section take precedence over conditions in above referenced Section.
   2. Provide submittals promptly in accordance with schedule and in such sequence as to cause no delay in work or in work of any other division.

3. Submittals for each specification section shall be submitted in a single package. However, it is not required (nor desired) for all products to be submitted concurrently. Rather, submittals may be staggered based on schedule and required equipment release dates.
4. Allow 15-working days for review, unless the Owner's Representative agrees to accelerated schedule.
5. For substitutions, list any features or characteristics that are not strictly in compliance with specifications. If none are listed with the submittal, Contractor is guaranteeing that substituted product is functionally equivalent to the specified product in accordance with Paragraph 1.7.
6. Submittal reviews by the Owner's Representative are intended to assist the Contractor in complying with the design intent and requirements of the drawings and specifications. Reviews do not relieve the Contractor from compliance with these requirements, and comments or lack thereof do not constitute approval of changes in these requirements.

C. Submission and Resubmission Procedure
1. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as "SUBMITTAL 23xxxx-01"
2. Each resubmittal shall have the original unique serial number plus unique revision number such as "SUBMITTAL 23xxxx-01 REVISION 1"
3. Submit in format specified below. Submissions made in the wrong format will be returned without action.
    a. Product Submittals: One copy in word-searchable electronic format per Paragraph 1.4. Submit each specification section in a separate file named with unique name and number described above.
    b. Shop Drawings:
        1) One copy in word-searchable electronic format per Paragraph 1.4.
        2) One paper copy only if requested by Owner
    c. Samples: As indicated in each specification section
4. Owner's Representative will return a memo or mark-up of submittal with comments and corrections noted where required.
5. Make corrections
    a. Revise initial submittal to resolve review comments and corrections.
    b. Indicate any changes that have been made other than those requested.
    c. Clearly identify resubmittal by original submittal number and revision number.
6. Resubmit revised submittals until no exceptions are taken.
7. Once submittals are accepted with no exceptions taken, provide
    a. Complete submittal of all accepted products in a single electronic file for each specification section.
    b. Photocopies or electronic copies for coordination with other trades, if and as required by the General Contractor or Owner's Representative.

D. Product Data Submittals
1. Contents
    a. Manufacturer's name and model number
    b. All information required to completely describe materials and equipment and to indicate compliance with drawings and specifications, including, but not limited to:
        1) Schedule when more than one of each item is covered by submittal
        2) Physical data, as applicable
            a) Dimensions
            b) Weight
            c) Finishes and colors
            d) Dimensional shop drawings
        3) Performance data, as applicable
            a) Rated capacities

b) Performance curve
c) Operating temperature and pressure
d) Sound power levels
4) Flow and wiring diagrams as applicable
5) Description of system operation
c. All other pertinent information requested in individual sections
2. Format
a. See Division 1 Shop Drawings, Product Data and Samples
b. Identify clearly if submittal is substitution: Refer to Paragraph 1.7
c. Reference specification Division, Section, Title, Paragraph and Page number or drawing number as applicable
d. Use same nomenclature, legend, symbols and abbreviations on submittal material as used in contract documents

E. Layout Shop Drawings
1. Drawings shall be developed using 3D software such as CAD-Duct and CAD-Pipe that is compatible with Navisworks to minimum Level of Development 350.
2. Shop fabrication, coordination and installation drawings by the Contractor, are for the Contractor's use and shall be the Contractor's responsibility. These Drawings indicate where the Contractor intends to install the material and equipment as required by the Contract Documents. Do not submit shop fabrication documents unless requested. Use of contract documents or electronic files of contract documents for shop drawings is not sufficient.
3. Prepare and submit Shop Drawings for all Work deviating from that indicated on Contract Drawings. Clearly indicate deviations.
4. Review is not intended to verify dimensions or quantities, or to coordinate items shown on these Drawings. Review is for general conformance with design concept of the Project and general compliance with the information given in the Contract Documents. Contractor is responsible for dimensions, which shall be confirmed and correlated at the Jobsite, for fabrication processes and techniques or construction, for coordination of Work with that of all other trades and the satisfactory performance of Work.
5. Prepare and submit layout drawings, sections and details for following areas:
a. Fan rooms
b. All duct shafts
c. All heating and cooling duct mains up to taps to VAV boxes
6. Drawings shall show work of all trades including but not limited to:
a. Ductwork
b. Piping: All Trades
c. Mechanical Equipment
d. Electrical Equipment
e. Main Electrical conduits and bus ducts
f. Equipment supports and suspension devices
g. Structural and architectural constraints
h. Show location of
1) Valves: manual and automatic
2) Piping specialties
3) Dampers: fire/smoke, automatic and manual volume, etc.
4) Access doors
5) Control and electrical panels
6) Others as required for clear coordination
7. Drawings shall indicate coordination with work specified in other Divisions which must be coordinated with work specified under Division 23 HVAC, including, but not limited to:
a. Irrigation equipment and piping
b. Elevator equipment
c. Building vacuum cleaning systems

d. Pneumatic tube systems
e. Cable trays
f. Computer equipment
g. Others as required

8. Submission of drawings
   a. See Division 1 Shop Drawings, Product Data and Samples.
   b. Submit to other trades for review of space allocated to all trades.
   c. Revise drawings to compensate for requirements of existing conditions and conditions created by other trades.
   d. Ensure that each trade has coordinated work with other trades
   e. Submit with stamps of General and all other applicable Contractors, initialed and signed certifying
      1) Review of submittal
      2) Verification of products, field measurements and field construction criteria
      3) Coordination of information in submittal with requirements of work of this Division and other divisions of Contract Documents
   f. No layout shop drawing will be reviewed without stamped and signed coordination assurance by the Contractor.

F. Samples
   1. Submit as required in each specification section.

1.6 COMPLETION REQUIREMENTS

A. Procedure
   1. Until the documents required in this section are submitted and approved, the system will not be considered “accepted.”
   2. Before requesting acceptance of work, submit one set of Completion Documents for review and approval of Owner’s Representative.
   3. After review, furnish quantity of sets indicated below to Owner.
   4. Format
      a. See Paragraph 1.6H for required format of Completion Documents

B. Operating and Maintenance (O&M) Manual
   1. In accordance with requirements of Division 1 Operating and Maintenance and as follows
   2. O&M Manual shall include but is not limited to the following
      a. Complete Product Data Submittals per Paragraph 1.5D so that the details of the device are known. This shall include only final approved submittals; rejected early submittals shall be stripped.
      b. Manufacturer's name, model number, service manual, spare-parts list and descriptive literature for all components
      c. Operating instructions
      d. Maintenance and repair requirements
      e. Wiring diagrams
      f. Requirements for special tools, test kits and calibration instructions
      g. Replacement parts list
      h. Valve tag directory
      i. Name, address and phone number of contractor’s equipment suppliers and service agencies

C. Record Drawings
   1. Keep up-to-date during progress of job one set of Mechanical Drawings indicating the Record installation. In addition to changes made during course of Work, show following by dimension from readily obtained base lines

a. Fully illustrate all revisions made by all crafts in course of work
b. Include all field changes, adjustments, variances, substitutions and deletions, including all Change Orders
c. Exact location, type and function of concealed valves, dampers, controllers, piping, air vents and piping drains
d. Exact size, invert elevations and location of underground and under floor piping and ducts

2. Progress drawing set shall be available for inspection by Owner's Representative weekly
3. Update shop drawings and record drawings to reflect revisions and additional data listed above at completion of Project
   a. Original engineering design drawings will be provided to Contactor in electronic format compatible with Revit or AutoCAD version 2013 or later. Update to become record set.
   b. Drawings required to be updated if revisions were made
      1) Floor plans
      2) Shop drawings
      3) Sections
      4) Riser diagrams

D. Test and Balance Reports
   1. See Section 230593 Testing, Adjusting and Balancing

E. Commissioning Reports
   1. See Section 230800 Mechanical Commissioning and 250000 Building Automation Systems

F. Training Materials
   1. See Section 230800 Mechanical Commissioning and 250000 Building Automation Systems

G. Miscellaneous Certificates
   1. Pressure and Leakage Test documentation/certificates
   2. Training/Instruction completion certificates
   3. Fire Marshal and Fire Department approvals of system, as required
   4. Final inspection certificate signed by governing authorities
   5. Warranty period, including start and end period
   6. Field test report, including as applicable
      a. Startup documents with date and name of technician
      b. Piping pressure tests
      c. Duct leakage and pressure tests
      d. Drain pan drainage tests
      e. Letters from manufacturers certifying their supervision of equipment installation and start-up procedures
      f. Others as specified herein

H. Format of Completion Documents
   1. Provide the type and quantity of media listed in table below
   2. Where indicated in table, the electronic files shall be stored on the BAS systems' Operator Workstation. See Division 25 Building Automation Systems.

	Document	Paper (binder or bound)	Electronic	
			Loaded onto Flash Drive	Loaded onto Operator Workstation
1.	O&M Manuals (including submittals)	3	1	1
2.	Record Drawings	2 Full size 2 Half size	1	1
3.	Test and Balance Report	5	1	–

	Document	Paper (binder or bound)	Electronic	
			Loaded onto Flash Drive	Loaded onto Operator Workstation
4.	Commissioning Reports	5	1	–
5.	Miscellaneous Certificates	1	–	–
6.	Warranty documents	1	–	–
7.	Training materials	1 per trainee	1	1

1.7 SUBSTITUTIONS AND PRODUCT OPTIONS

A. Contractor's Options
   1. For products specified only by functionality and/or reference standard, select product meeting that functionality and/or standard, by any manufacturer.
   2. For products specified by manufacturer and model number
      a. Where “Or Equal” lists specific alternative manufacturers including specific model numbers, any of these specific products may be selected and will not be considered a substitution.
      b. Where “Or Equal” lists specific alternative manufacturers but no specific model numbers
         1) Functionally equivalent products by listed alternative manufacturers may be selected.
         2) Functionally equivalent products by manufacturers not listed may be selected but may be rejected by Owner’s Representative for any reason if there is any question with respect to functional equivalency including unfamiliarity with manufacturer and local representation.
         3) Functional equivalent products to the product specified are those that
            a) Are equal or better in quality, function, capacity, efficiency, serviceability, local support, etc.
            b) Fully meet the product specifications unless otherwise approved by the Owner’s Representative
            c) Meet site and application constraints including but not limited to size, weight, appearance, and clearance requirements.

B. Substitution Requirements
   1. Where substitutions are proposed for products indicated in design documents, the Contractor shall take full responsibility for coordinating with others the requirements of the proposed substitution including but not limited to:
      a. Adequate space, including service access space
      b. Power and other electrical connections
      c. Pads or other equipment supports
      d. Control devices and interfaces
   2. Include all costs for redesign and other work required by all disciplines affected by a substitution.

1.8 DESCRIPTION OF BID DOCUMENTS

A. Specifications
   1. Specifications, in general, describe quality and character of materials and equipment
   2. Specifications are of simplified form and include incomplete sentences
   3. Words or phrases such as "The Contractor shall," "shall be," "furnish," "provide," "a," "an," "the," and "all" have often been omitted for brevity

B. Drawings

1. Drawings in general are diagrammatic. Intention is to show size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement.
2. Scaled and figured dimensions are approximate and are for estimating purposes only. Indicated dimensions are limiting dimensions where noted. Duct and piping elevations are indicated for initial coordination; final requirements shall be determined by the Contractor after final coordination with other trades.
3. Before proceeding with work check and verify all dimensions in field.
4. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
5. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom and avoid architectural openings, structural members and work of other trades.
6. For exact locations of building elements, refer to dimensional Architectural and Structural drawings.

C. Do not use equipment exceeding dimensions indicated on drawings or equipment or arrangements that reduce required clearances or exceed specified maximum dimensions.

D. If any part of Specifications or Drawings appears unclear or contradictory, apply to Owner's Representative for an interpretation and decision as early as possible.
   1. Do not proceed with work without the decision of the Owner's Representative.

1.9 ALTERNATES

A. Refer to Section 01230 Alternates for possible effect on this Section.

1.10 DEFINITIONS

A. Definitions of term used in Division 23 HVAC may differ from those given in general and supplementary conditions and take precedence over them.

B. "Provide": to furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.

C. "Supply": to purchase, procure, acquire and deliver complete with related accessories.

D. "Work": labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

E. "Piping": pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.

F. "Wiring": raceway, fittings, wire, boxes and related items.

G. "Concealed": embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.

H. "Exposed": not installed underground or "concealed" as defined above.

I. "Indicated," "shown" or "noted": as indicated, shown or noted on drawings or specifications.

J. "Reviewed," "approved," or "directed": as reviewed, approved, or directed by or to Owner's Representative.

K. "Motor Controllers": starters, variable speed drives, and other devices controlling the operation of motors.

L. "Control or Actuating Devices": automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

1.11 PROJECT CONDITIONS

A. Examine site related work and surfaces before starting work of any Section
   1. In case of conflict, the most stringent takes precedence
   2. For purposes of clarity and legibility, Drawings are essentially diagrammatic to extent that many offsets, bends, unions, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Especially note a number of required duct and pipe offsets to coordinate with structure and not shown. Coordinate dimensioned conditions, including invert elevations, with other trades prior to installation by any trade.
   3. Exact routing of piping, ductwork, etc. shall be governed by structural conditions, obstructions. Not all offsets in ductwork or piping are shown on the Mechanical Drawings. Determine which item to offset or relocate. Maintain required slope in piping. Make use of data in Contract Documents. In addition, Owner's Representative reserves right, at no additional cost to the Owner, to make any reasonable change in location of mechanical items, exposed at ceiling or on walls, to group them into orderly relationships or increase their utility. Verify Owner's Representative's requirements in this regard prior to rough-in.
   4. Take dimensions, location of doors, partitions, similar physical features from Architectural Drawings. Verify at Site under this Division. Consult Architectural Drawings for exact location of outlets to center with Architectural features, panels, etc., at the approximate location shown on mechanical Drawings.
   5. Mounting heights of brackets, outlets, etc., as required
   6. Report to Owner's Representative, in writing, conditions which will prevent proper provision of this work
   7. Beginning work of any Section without reporting unsuitable conditions to Owner's Representative constitutes acceptance of conditions by Contractor
   8. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to the Owner

B. Coordination
   1. Work out all "tight" conditions involving Work specified under this Division and Work in other Divisions in advance of installation. If necessary, and before Work proceeds in these areas, prepare supplementary Drawings under this Division for review showing all Work in congested area. Provide supplementary Drawings, additional Work necessary to overcome congested conditions, at no additional cost to the Owner.
   2. Conflicts: Difference or disputes concerning coordination, interference or extent of Work between sections shall be decided as follows
      a. Install mechanical and electrical systems in the following order of preference (those trades listed below another must reroute to resolve the conflict):
         1) Drain piping required by code to be sloped
         2) Supply air and exhaust air ductwork connected to fans
         3) Electrical conduit 4 inches and larger
         4) Hydronic piping connected to pumps
         5) Domestic water piping
         6) Fire sprinkler piping
         7) Electrical conduit smaller than 4 inches

8) Transfer ducts and other ductwork not connected to fans
9) Control system piping and wiring

b. Continued disputes shall be decided by Contractor and Contractor's decision, if consistent with Contract Document requirements, shall be final.

3. Supervision: Personally, or through an authorized and competent representative, constantly supervise the work from beginning to completion and, within reason, keep the same foreman and workmen on the Project throughout the Project duration.
4. Provide templates, information and instructions to other Divisions to properly locate holes and openings to be cut or provided.
5. The drawings govern in matters of quantity, and the specifications govern in matters of quality. In the event of conflict within the drawings involving quantities, or within the specifications involving quantities, or within the specifications involving quality, the greater quantity and higher quality shall apply. Such discrepancies shall be noted and clarified in the Bid. No additional allowances will be made because of errors, ambiguities, or omissions that reasonably should have been discovered during the preparation of the Bid.

C. Equipment Rough-In
1. Rough-in locations shown on Mechanical Drawings for equipment furnished by the Owner and for equipment furnished under other Divisions are approximate only. Obtain exact rough-in locations from following sources
a. From Shop Drawings for equipment provided under this contract
b. From Owner's Representative for Owner-furnished-Contractor installed equipment
c. From existing equipment where such equipment is relocated under this Contract
2. Verify mechanical characteristics of equipment before starting rough-in. Where conflict exists between equipment and rough-in shown on Drawings obtain clarification from Owner's Representative and provide as directed by the Owner's Representative at no additional cost to the Owner.
3. Make final connections

1.12 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping or ductwork
1. Prohibited, except as noted, in
a. Electric rooms and closets over equipment, as restricted by CEC
b. Telephone rooms and closets
c. Elevator machine rooms
d. Electric switchboard room
2. Prohibited, except as noted, over or within 5 feet of
a. Transformers
b. Substations
c. Switchboards
d. Motor control centers
e. Standby power plant
f. Bus ducts
g. Electrical panels

B. Drip pans under piping
1. Where piping is located over any electrical equipment listed above; reroute piping if possible rather than use drip pan
2. 18 gage galvanized steel
3. 18 gage copper
4. Reinforced and supported
5. Watertight

6. With 1-1/4 inch drain outlet piped to floor drain or service sink

1.13 PRODUCT DELIVERY, HANDLING AND STORAGE

A. See Division 1 Product Requirements

B. Deliver equipment in its original package to prevent damage or entrance of foreign matter. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Provide protective coverings during construction.

C. Handle and ship in accordance with manufacturer's recommendations

D. Identify materials and equipment delivered to Site to permit check against approved materials list, reviewed with no exceptions taken Shop Drawings

E. Protect from loss or damage. Replace lost or damaged materials and equipment with new at no additional cost to the Owner

F. Where necessary, ship in crated sections of size to permit passing through available space

1.14 PROJECT MANAGEMENT AND COORDINATION SERVICES

A. See Division 1 Project Coordination

B. Overview: Provide a project manager/engineer for the duration of the Project to coordinate the Division 23 HVAC work with all other trades. Coordination services, procedures and documentation responsibility shall include, but shall not be limited to the items listed in this section.

C. Review of shop drawings prepared by other subcontractors
   1. Obtain copies of all shop drawings for equipment provided by others that require electrical service connections or interface with Division 23 HVAC work.
   2. Perform a thorough review of the shop drawings to confirm compliance with the service requirements contained in the Division 23 HVAC contract documents. Document any discrepancy or deviation as follows:
      a. Prepare memo summarizing the discrepancy
      b. Provide a copy of the specific shop drawing, indicating via cloud, the discrepancy
   3. Prepare and maintain a shop drawing review log indicating the following information
      a. Shop drawing number and brief description of the system/material
      b. Date of your review
      c. Indication if follow-up coordination is required

D. Request for information (RFI)
   1. See Division 1 Request For Information

1.15 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by the Owner’s Representative

B. Advise Owner’s Representative that work is ready for review at following times:
   1. Prior to backfilling buried work

2. Prior to concealment of work in walls and above ceilings
3. When all requirements of Contract have been complete

C. Neither backfill nor conceal work without Owner's Representative's consent.

D. Maintain on job set of Specifications and Drawings for use by Owner's Representative's
1. Include all change orders.

E. Contractor is responsible for construction methods, sequences and safety precautions

1.16 SCHEDULE OF WORK

A. In accordance with Division 1 Contract Schedules and as follows:
1. Arrange work to conform to schedule of construction established or required to comply with Contract Documents
2. In scheduling, anticipate means of installing equipment through available openings in structure

B. Confirm in writing to Owner's Representative, within 35-days of signing of contract, anticipated number of days required to perform test, balance, acceptance testing and commissioning of mechanical systems. Schedule test, balance and acceptance testing of mechanical systems as follows:
1. Submit for review at this time, names and qualifications of test and balancing agencies to be used
2. Test & Balance and commissioning must occur after completion of mechanical systems, including all control calibration and adjustment, and requires substantial completion of the building, including closure, ceilings, lighting, partitioning, etc.
3. Allow 21-days after test and balance for system commissioning and life safety testing (where applicable)
4. Complete and test all systems early enough to enable completion of commissioning prior to Owner move-in.
5. Provide post construction purge direction immediately before occupancy. See Paragraph 3.8.

1.17 CUTTING AND PATCHING

A. See Division 1 Cutting, Patching and Patching

1.18 UTILITY CONNECTIONS

A. Point of connection to on-site chilled water and hot water piping mains shall be just inside the building envelope. Piping outside the envelope and sealing of envelope openings shall be specified under Division 33.

1.19 WARRANTY

A. In accordance with Division 1 Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows.

B. Warranty all materials, equipment, apparatus and workmanship to be free of defective materials and faulty workmanship for period of one year from date of filing of Notice of Completion or upon beneficial use, at the direction of the Owner's Representative (see Paragraph 3.4A.1).

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner's Representative to be defective or faulty.

D. This guarantee also applies to services including instructions, adjusting, testing, noise, balancing, etc.

E. Furnish Manufacturers' standard Warranties in excess of one year.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Alternate manufacturers as identified in each section will be considered under conditions specified in Paragraph 1.7 of this section.

B. Identify materials, equipment by manufacturer's name, nameplate data. Remove unidentified materials, equipment from Site.

C. Equipment specified by manufacturer's number shall include all accessories, controls, etc., listed in catalog as standard with equipment. Furnish optional or additional accessories as specified.

D. Where no specific make of material or equipment is mentioned, any first class product of reputable manufacturer may be used, provided it conforms to requirements of system and meets with acceptance.

E. Provide an authorized representative to constantly supervise work of this Division, check all materials prior to installation for conformance with Drawings, Specifications, reviewed Submittals and reviewed Shop Drawings.

F. Conform to conditions shown and specified. Coordinate with other trades for best possible assembly of combined Work. Relocate equipment when necessitated by failures to coordinate Work or to advise Owner's Representative of conflicts in writing.

G. Material and Equipment-General Requirements
   1. New
   2. Approved for use by State Fire Marshal and local building inspection department when applicable
   3. Testing agency labeled or with other identification wherever standards have been established
   4. Owner's Representative reserves right to reject items not in accordance with Specification either before or after installation
   5. Comprised to render complete and operable systems; provide additional items needed to complete installation to realized design
   6. Compatible with space allocated; modifications necessary to adjust items to space limitations at Contractor's expense
   7. Installed fully operating and without objectionable noise or vibration
   8. Design of mechanical systems is generally based on product of the first named manufacturers cited. Where systems for product installed necessitate modification of systems shown on drawings, Contractor is responsible for installation of systems appropriate to product installed.

H. Electrical Requirements
   1. Electrical Work performed under Division 23 HVAC shall conform to requirements of Division 26 Electrical
   2. Provide weatherproof devices and installation for out-of-doors work

PART 3 EXECUTION

3.1 INSPECTION

A. Verify that conditions are satisfactory for the installation of materials and equipment. Notify Owner's Representative if conditions are not satisfactory and do not commence work until conditions have been corrected.

3.2 INSTALLATION

A. Install materials and equipment in compliance with governing codes.

B. Use printed descriptions, specifications and recommendations of manufacturers as a guide for installation of Work. Follow in all cases where manufacturers' of articles used furnish directions covering points not specified or shown.

C. Equipment
   1. See Division 1 Supporting From Building Structure
   2. Assemble equipment which is required to be field assembled under the direct supervision of the manufacturers' agent
   3. Prior to the final acceptance submit letters from the manufacturers that equipment has been assembled under the direct supervision of the manufacturers' agent
   4. Accurately set and level equipment with supports neatly placed and properly fastened
   5. Properly fasten equipment in place with bolts to prevent movement in earthquake
   6. Coordinate the installation of equipment with openings in structure
   7. Coordinate and fully dimension steel supports for mechanical equipment where shown on drawings with installing contractor
   8. Provide all roof curbs for roof mounted fans, flues, piping and duct penetrations, etc.
   9. Concrete
      a. Concrete work, include forming, steel bar reinforcing, cast-in-place concrete, finishing and grouting is specified under Division 3 Concrete
      b. Coordinate and fully dimension concrete housekeeping pads and curbs with installing contractor; dimensions shall be as required for structural and seismic requirements, see Section 230548 Vibration and Seismic Control
      c. Coordinate inertia base fill with installing contractor

D. Electrical
   1. See Division 26 Electrical
   2. Install electrical devices with code required clearances and access
   3. Assist the electrical contractor in the proper connecting of all electrical wiring and equipment required for mechanical equipment

E. Sleeves, Chases and Concrete Inserts
   1. Provide all required sleeves, chases, concrete inserts, anchor bolts, etc.
   2. Sleeves, chases are prohibited in structural members, except where shown or as directed by Owner's Representative in writing
   3. Embed no piping in concrete or masonry

F. Waterproof Construction
   1. Comply with Division 7 Thermal and Moisture Protection.

2. Include membrane clamps, sheet metal flashing, counter flashing, caulking and sealant as required for waterproofing of mechanical penetrations and sealing penetrations in or through exterior walls, floors, roofs, and foundation walls.
3. All penetrations through vapor barriers at slabs on grade shall be taped and made vapor tight.
4. Provide galvanized sheet metal weather protection canopies, hoods or enclosures over all out-of-doors equipment, the operation or maintenance of which would be impaired by rain water; this requirement applies to damper operators and bearing, damper motors, controls and instruments; see other Sections in this Division for application of this requirement to motors, drive, ducts and fans.

G. Restoration of Damage
1. Repair or replace, as directed by Owner's Representative, materials and parts of premises which become damaged.
2. Remove replaced parts from premises at no additional cost to the Owner.

H. Review architectural drawings and coordinate with Architect and other contractors to be sure that all architectural shafts, plenums, rated duct enclosures etc. required for mechanical systems are properly located and dimensioned.

I. Access Panels and Doors
1. Product specified under Division 8 Openings and Division 5 Metals:
a. Coordinate size requirements and exact location with Contractor who will provide and install access doors
b. Minimum Sizes: 18 inches by 18 inches unless otherwise shown on Drawings or approved by Owner Representative
2. Provide where shown, or required by Regulatory Agencies, for access of all concealed equipment such as terminal units, valves, fire/smoke dampers, etc., for Mechanical Work:
a. Equipment shall be located wherever practical over accessible ceilings or rooms to avoid access doors
b. Access doors shall not be used solely for access to balancing dampers; use instead remote control devices specified under Section 233300 Duct Accessories

J. Openings
1. Coordinate and fully dimension all openings in walls, floors, roofs and structural elements required for mechanical work.
2. Provide all required fire-stopping around pipe, duct and other penetrations required for mechanical work in rated partitions where required by code.
3. Fire damper openings: Contractor shall provide damper UL installation requirements to contractor installing partitions to ensure construction complies with listing.
4. Air outlet openings
a. Contractor shall coordinate exact locations of air outlets in floors, walls and ceilings with contractor installing partition.
b. Contractor shall coordinate additional T-bar or spline required to accept air outlets with contractor providing and installing ceiling and associated materials.

3.3 PROTECTION OF MATERIALS

A. See Division 1 Product Requirements.

B. Completely cover motors and other moving machinery to protect from dirt and water during construction.

C. During transport to and storage on the construction site, and during rough-in until final connections are made, all ductwork and other related air distribution component openings shall be covered with plastic to prevent contamination from dust, water, and debris.

D. Cap all openings in pipe and ductwork daily to protect against entry by foreign matter.

E. Material, equipment or apparatus damaged because of improper storage or protection will be rejected
   1. Remove from site and provide new, duplicate, material, equipment or apparatus in replacement of that rejected.
   2. Any porous materials, such as duct liner or flexible ductwork that becomes wet; for example, due to rain shall be replaced; drying is not sufficient (due to possible microbial contamination).

F. Perform Work in manner precluding unnecessary fire hazard.

3.4 ADJUSTMENT

A. Preliminary Operation
   1. Operate any portion of installation for Owner's convenience if so requested by Owner's Representative. Such operation does not constitute acceptance of Work as complete but does constitute beneficial use, see Paragraph 1.19B. Cost of utilities, such as electrical power, will be borne by the Owner if operation is requested by Owner's Representative.

B. Startup Service
   1. Prior to startup, ensure that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrications, venting fan balance, controls and installed and properly set relief and safety valves. See pre-function tests in Division 23 HVAC.
   2. Start and operate all systems.
   3. Provide services of factory trained technicians for startup of major equipment and systems including boilers, fire pumps, etc.
   4. Adjusting: See Section 230593 Testing, Adjusting and Balancing.
   5. Functional Testing: See Division 25 Building Automation Systems.
   6. Life Safety Testing
      a. Assist Division 26 Electrical contractor in testing fire alarm controls, including control of smoke dampers and of fan systems.
      b. Correct any problems related to equipment supplied under Division 23 HVAC.
      c. Complete the control matrix with details such as fan tags, FSD tags, etc. based on control matrix provided with Life Safety Report.
      d. Assist Life Safety System commissioning agent in testing and commissioning Life Safety System.
      e. Provide all tests, air balance and start-up personnel required to start and commissioning the system and for assisting the design/construct team in demonstrating system compliance with the local fire district and building department

C. Noise
   1. Cooperate in reducing any objectionable noise or vibration caused by mechanical systems to the extent of adjustments to specified and installed equipment and appurtenances.
   2. Completely correct noise problems caused by failure to make installation in accordance with Contract Documents, including labor and materials required as a result of such failure, at no additional cost to the Owner.

3.5 SPECIAL TOOLS

A. Furnish to Owner at completion of work one set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of this Division.

3.6 CLEANING

A. See Division 1 Closeout Procedures, Final Cleaning and Extra Material

B. Thoroughly clean equipment, fans, pumps, motors, piping and other materials under this. Division free from all rust, scale and all other dirt before any covering or painting is done, or the systems put in operation; leave in condition satisfactory to Owner's Representative.

C. At all times keep the premises free from accumulation of waste material and debris caused by his employees. At the completion of the Project, and at other times as Owner's Representative may direct, remove refuse from within and around the building. All tools, scaffolding and surplus materials shall also be removed, leaving the Site of his Work clean.

D. Completely cover all motors and other moving machinery to prevent entry of dirt and water during construction.

E. Effectively cap all openings into ducts and pipes to keep moisture and foreign matter out during construction

3.7 PAINTING

A. Painting
   1. Piping exposed to outdoors
      a. One coat primer
      b. Two coat alkyd oil paint, UV resistant for PVC piping, color as indicated
      c. Not required for copper, galvanized steel, or insulated piping
   2. Steel hangers and supports exposed to outdoors
      a. One coat primer
      b. Not required for galvanized steel
   3. Interior of ductwork and duct accessories, including insulation stick pins, at air outlets as far back as visible from occupied spaces
      a. Flat black
   4. Marred surfaces of factory painted equipment
      a. Spot coat to match adjacent coat
   5. Insulation exposed to sunlight: See Section 230700 Mechanical Insulation

B. Execution
   1. Protect flooring and equipment with drip cloths.
   2. Paint and materials stored in location where directed.
   3. Oily rags and waste removed from building every night.
   4. Wire brush and clean off all oil, dirt and grease areas to be painted before paint if applied.
   5. Workmanship
      a. No painting or finishing shall be done with
         1) Dust laden air
         2) Unsuitable weather conditions
         3) Space temperature below 60 degrees Fahrenheit
      b. Pipes painted containing no heat and remain cold until paint is dried.
      c. Paint spread with uniform and proper film thickness showing no runs, sags, crawls or other defects.

d. Finished surfaces shall be uniform in sheen, color and texture.
e. All coats thoroughly dry before succeeding coats are applied, minimum 24 hours between coats.
f. Primer undercoat of slightly different color for inspection purposes

6. Piping continuously painted in all exposed areas

C. Paint
1. High gloss medium or long alkyd paint
2. Best grade for its purpose
3. Deliver in original sealed containers.
4. Apply in accordance with manufacturer's instructions.

D. Colors
1. Colors as directed by Owner's Representative unless specified herein.
2. Condenser water piping: pale green
3. Interior of ductwork as far back as visible from outside: flat black
4. Uncoated hangers, supports, rods and insets: dip in zinc chromate primer

E. Factory finish
1. Ceiling and wall mounted air outlets in acoustical tile ceilings: Baked white enamel
2. Aluminum air outlets that are not to be painted: anodized

F. Marred surfaces of prime coated equipment and piping: spot prime coat to match adjacent coat

G. Properly prepare Work under this Division to be finish painted under Division 9 Painting

H. Provide moisture resistant paint for exterior painting and heat resisting paint for hot piping, equipment and materials

I. Factory Finishes
1. Exposed fan coil units: baked enamel
2. Unit ventilators and unit heaters: baked enamel
3. Fans, pumps, compressors, tanks and like items
4. Air handlers, pumps, water heaters and like items where exposed

J. For the following, provide factory prime coat. Also, provide factory finish painting on each if not specified in Painting Division
1. Other air outlets

K. Paint all equipment out-of-doors and equipment supports with two coats of weather resistant enamel

L. Protect all finished surfaces of fixtures with heavy paper pasted thereon, or by other means, throughout the period of construction

M. Refinish Work supplied with final finish under this Division if damaged under this Division to satisfaction of Owner's Representative

3.8 OPERATION OF SYSTEMS AND POST-CONSTRUCTION PURGE

A. This section is provided to
1. Minimize the possibility that ducts and air plenums will be contaminated with construction debris.

2. Ensure that off-gassing volatile organic compounds (VOCs) are not transferred from one area to another.
3. Purge VOCs that have off-gassed from construction materials and furnishings prior to occupancy.

B. Construction Period
1. Fan systems shall not be operated during construction (e.g. to assist in drying walls, space conditioning, etc.) unless approved in writing by Owner's representative.

C. Test and Balance Period
1. Operation of fan systems for test and balance shall only occur after the area served by air systems and all air plenums have been thoroughly cleaned of dust and debris. No construction work that generates dirt and particles shall be occurring while fan systems are in operation.
2. Procedure
   a. Install temporary construction filters (prefilters) on all supply air systems. Do not install high efficiency final filters at this time.
   b. Adjust systems with economizer capability to supply 100% outdoor air, no recirculated air.
   c. Perform test and balance work per Section 230593 Testing, Adjusting and Balancing) at zone level.
   d. Immediately prior to the start of the post-construction purge period (see below), remove and discard construction filters and install high efficiency final filters.
   e. Conduct test and balance work at supply air system. System may be temporarily converted from 100% outdoor air to minimum outdoor air as required for tests only; return to 100% outdoor air configuration after tests.

D. Post-Construction Purge Period
1. Schedule
   a. Start after
      1) All construction work that produces dust or VOCs is complete, except for minor touch-up painting work and installation of furnishings
      2) All test and balance work is complete on all air systems with 100% outdoor air capability
      3) Temperature control systems are operational
      4) Heating systems are fully operational
   b. End after a time period determined from the following equation, calculated for each fan system individually, where T is time in days, A is the floor area served by the system in ft^2 and CFM is the outdoor air capacity of the system in cfm:
$$T = \frac{14000 * A}{CFM * 60 * 24}$$
   c. The space may only be occupied
      1) After the purge time period calculated above is complete; or
      2) After time T' calculated from the equation below provided the space is ventilated with 100% outdoor air until the total purge time period calculated above is compete.
$$T' = \frac{3500 * A}{CFM * 60 * 24}$$
2. Procedure
   a. Adjust systems with economizer capability to supply 100% outdoor air, no recirculated air.
   b. Ensure that high efficiency final filters are in place.
   c. Run fan systems supplying 100% outdoor air during entire purge period.
   d. Enable boilers and zone controls and set heating setpoints to 70^oF.
   e. Cooling systems may be enabled or disabled.
3. Because final filters will not be challenged with contaminants in the return air, they do not have to be replaced after the flush-out period.

3.9 FIELD QUALITY CONTROL

A. See Division 1 Quality Control

B. Tests
   1. Perform as specified in individual sections and as required by authorities having jurisdiction
   2. Perform commissioning work
      a. Perform pre-function tests as specified in Division 23 HVAC
      b. Perform functional and post-occupancy tests. See Division 25 Building Automation Systems
   3. Duration as noted

C. Provide required labor, material, equipment and connections

D. Furnish written report and certification that tests have been satisfactorily completed

E. Repair or replace defective work, as directed by Owner's Representative in writing, at no additional cost to the Owner

F. Restore or replace damaged work due to tests as directed by Owner's Representative in writing, at no additional cost to the Owner

G. Restore or replace damaged work of others, due to tests, as directed by Owner's Representative in writing, at no additional cost to the Owner

H. Remedial work shall be performed to the satisfaction of the Owner's Representative, at no additional cost to the Owner, including
   1. Work related to all Division 23 HVAC pre-functional tests
   2. Division 23 HVAC work related to Section 019100 Commissioning
   3. Division 23 HVAC work related to Section 230593 Testing, Adjusting and Balancing
   4. Division 23 HVAC work related to Section 230800 Mechanical Commissioning

I. Remedial work shall include performing any commissioning or other tests related to remedial work an additional time at no additional cost to the Owner

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230513

MOTORS AND CONTROLLERS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Motors
   2. Variable speed drives
   3. Motor controllers where not provided as part of mechanical equipment

1.2 REFERENCE STANDARDS

A. ABMA 9 Load Ratings and Fatigue Life for Ball Bearings

B. ABMA 11 Load Ratings and Fatigue Life for Roller Bearings

C. ANSI/IEEE 112 Test Procedure for Polyphase Induction Motors and Generators

D. ANSI/NEMA MG 1 Motors and Generators

E. ANSI/NFPA 70 National Electrical Code

F. IEEE Standard 519-1992, IEEE Guide for Harmonic Content and Control

G. NEC 430.120, Adjustable-Speed Drive Systems.

H. NEMA ICS 7.0, AC Adjustable Speed Drives

I. Underwriters Laboratories UL 508 Standard for Industrial Control Equipment

J. Underwriters Laboratories UL 508A Standard for Industrial Control Panels

K. Underwriters Laboratories UL 508C Standard for Power Conversion Equipment

1.3 DEFINITIONS

A. VSD: Variable speed drive

B. ECM: Electrically Commutated Motor

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Motors	R	R		R
Belts and Drives		R		
Variable Speed Drives	R	R		R

C. Submittals shall include certification from the motor manufacturer certifying compliance with NEMA MG-1, part 31 for motors that are driven by variable speed drives.

1.5 WARRANTY

A. Special Warranty: VSD warranty shall be 24 months from date of start-up certification including all parts, labor, travel time, and expenses.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Motors
   1. US Motors
   2. General Electric
   3. Gould Inc.
   4. Baldor
   5. Ebm-papst
   6. Or equal

B. Variable speed drives
   1. ABB
   2. Danfoss
   3. Yaskawa
   4. Or equal

2.2 MOTORS

A. General
   1. In accordance with NEMA, IEEE, and ANSI C50 standards
   2. Capacity
      a. Minimum horsepower indicated
      b. To operate driven devices under all conditions without overload
   3. Squirrel-cage induction type, NEMA Type "B: insulation class, continuous duty
   4. Speed
      a. 1750 RPM, unless otherwise indicated
      b. See schedules on drawings for other speeds

5. Minimum NEMA KVA/HP Locked Rotor Code:

HP Range	Code Letter
≤2	M
3	K
5	J
7.5-10	H
>10	G

6. Service factor: 1.15
7. Type unless otherwise scheduled on Drawings
   a. Voltage: As scheduled on Drawings
   b. 1/2 horsepower and smaller
      1) Single-phase, 60 hertz
      2) With built-in auto-reset thermal overload protection
   c. 3/4 horsepower and larger
      1) Three-phase, 60 hertz
      2) 50 horsepower and over: Reduced voltage start, suitable for star-delta starting
   d. Electrically Commutated Motor (ECM)
      1) Where scheduled on Drawings or equipment Specifications
8. Bearings
   a. Ball type, unless otherwise indicated
   b. Sealed, permanently lubricated, unless otherwise noted or not available in motor size
      1) One bearing size on both ends of the motor
      2) Minimum bearing life of
         a) 50,000 hours for belt-drive
         b) 130,000 hours for direct-drive

B. Enclosure
   1. Open drip-proof (ODP)
      a. Provide ODP motors unless otherwise indicated
   2. Totally enclosed (TEFC)
      a. Motors outside the building or otherwise exposed to the weather
      b. Non-ventilated: under 1/2 horsepower
      c. Fan-cooled: 1/2 horsepower and larger
   3. See schedules on drawings for other enclosures

C. Belt-connected motors
   1. Foundation slide base
   2. Shaft as required for aligning pulleys

D. Motors 1 horsepower and larger shall be NEMA Premium™ labeled and have guaranteed efficiencies equal to or exceeding NEMA Table 12-6D.

E. Motors driven by variable speed drives
   1. Shall be “inverter ready” motors that meet the requirements of NEMA MG-1 part 31
   2. Where used for pumps or fans (variable torque), shall have minimum 10:1 turndown and be capable of operating at 10 percent speed indefinitely
   3. Shall incorporate a design to prevent arcing through the motor bearings, such as: insulated bearings, ceramic bearings, grounded motor shafts such as those manufactured by AEGIS Ground Shafting Systems, or approved equal, for the following applications:
      a. Motors are larger than 75 HP
      b. The VSD runs near constant speed such as data center air handlers and VSDs used only to adjust for filter loading such as clean room air handlers
      c. Where indicated on Drawings

F. Electrically Commutated Motors (ECMs) ≤1 HP
    1. Brushless DC type with electronic commutation from 115 volt, 277 volt, or 480 volt single phase power to a DC signal
    2. Speed controllable from a minimum of 15% or less to 100% of full speed
    3. Minimum 80% efficiency at all speeds
    4. Include time delay relays or other electrical devices as necessary to limit motor in-rush current to 10 times the maximum motor running current.
    5. Provide one of the following as indicated on Drawings or Specifications
        a. Constant speed applications
            1) Potentiometer dial mounted on the exterior of the motor housing
            2) Programmed with fan-curve for "constant airflow"
        b. Variable speed applications
            1) 0-10 volt DC control signal input
            2) Signal configured to be proportional to fan speed, or to torque if speed not available.
            3) Where specified in other Sections: Motor shall shut off when speed signal is below 2 Vdc minimum.
            4) Where specified in other Sections, include 0-10 volt DC speed feedback output.
    6. The motor in-rush current, including transient in-rush currents of less than one 60 Hz cycle (0.016 seconds), shall not exceed 10 times the motor RLA. The manufacture shall include transient in-rush suppression circuit as required to achieve these values. The transient in-rush suppression circuit shall be ETL or UL listed by the manufacturer and shall be designed to be fail safe. The manufacturer shall submit actual factory recorded in-rush values recorded with a meter for the first 10 seconds of the motor starting for the complete assembly, including the current waveform of the initial transient current.
    7. Equal to Regal Beloit ECM

2.3 VARIABLE SPEED DRIVES

A. General
    1. All variable speed drives other than those that are factory packaged with equipment shall be supplied by one manufacturer.
    2. VSDs shall be completely assembled and tested by the manufacturer in an ISO 9001 & 14001 facility.
    3. All circuit boards shall be coated to protect against corrosion. Control boards shall be conformal coated to at least IEC 60721-3c2.
    4. Include factory installed door interlocked pad-lockable circuit breaker that will disconnect all input power from the drive and all internally mounted options and comply with Lock Out/Tag Out (LOTO) requirements of CEC 430.

B. Performance
    1. The VSD shall provide full rated output from a line of ±10% of nominal voltage. The VSD shall continue to operate without faulting from a line of +30% to -35% of nominal voltage.
    2. Overload rating of VSD shall be 110% of normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute.
    3. VSDs shall be capable of continuous full load operation in the following environmental conditions:
        a. Ambient temperature: 5°F to 104°F. Operation to 120°F shall be possible with a 10% reduction from VSD full load current
        b. Altitude: 0 to 3300 feet above sea level. Operation to 6600 feet shall be possible with a 10% reduction from VSD full load current
        c. Relative humidity: 0 to 95%, non-condensing

4. Efficiency shall be not less than 97 percent at rated voltage, current, and frequency and fundamental power factor shall not be less than 98 percent at all speeds and loads.

C. Electrical Characteristics
   1. Provide as a minimum 5% impedance line reactors. The 5% impedance may be from dual (positive and negative DC bus) reactors or 5% AC line reactors. VSDs with only one DC reactor shall include AC line reactors.
   2. VSD shall automatically mitigate harmonics throughout the effective load range using Swinging chokes or other devices designed to lower harmonics when VSD is at partial loads.
   3. Include Ferrite Core EMI/RFI/Common mode filters. The onboard filters shall allow the VSD assembly to be CE Marked and the VSD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2).

D. Equipment Protection and Safeties
   1. VSD shall:
      a. Be UL 508 listed for a minimum of 100 kA short circuit current rating (SCCR) without the need for external input fuses or external series rated combination circuit breakers.
      b. Include built in coordinated AC transient surge protection system consisting of 4 MOVs (phase to phase & phase to ground), capacitor clamp, 1600 PIV Diode Bridge and internal chokes.
      c. Automatically mitigate harmonics throughout the effective load range using Swinging chokes or other devices designed to lower harmonics when VSD is at partial loads.
      d. Protect itself against all normal transients and surges in incoming power line, any grounding or disconnecting of its output power, and any interruption or run away of incoming speed signal without time delay considerations. Protection is defined as normal shutdown with no component damage.
      e. Be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The VSD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay output shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false under-load condition.
      f. Protect itself against all phase-to-phase or phase-to-ground faults.
      g. Be able to start into a rotating load (flying start) at all speeds (forward or reverse) without trip.
      h. Ride through an input power dip of 3 cycles without trip.
      i. Operate properly at a -35% +30% voltage fluctuation from rated voltage.
      j. Operate properly at a 10 percent frequency variation from rated frequency.
      k. Employ three current limit circuits to provide trip-free operation: slow current regulation, rapid current regulation, and current limit switch-off limit. VSD shall be designed so that overcurrent trip shall be at least 315 percent of the drive's current rating.
      l. Withstand unlimited switching of the output under full load, without damage to the VSD. Operation of a disconnect switch between the motor and VSD shall not have an adverse effect on the VSD, whether the motor is operating or not. Controls conductors between the disconnect and the VSD shall not be required for the safe and reliable operation of the VSD.
      m. Withstand switching of the input line power up to 20 times per hour without damage to the VSD.
   2. Anti-regeneration circuit shall match the deceleration rate of the drive to that of the motor to prevent high bus voltage shutdown common to high inertia loads, such as fans.

E. Human-Machine Interface
   1. Keypad with backlit LCD
   2. Removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VSDs.
   3. Password protection against parameter changes

4. Hand-Off-Auto selections and manual speed control with “bumpless transfer” of speed reference when switching between “Hand” and “Auto” modes
5. “Help” button with built-in assistance for programming and troubleshooting
6. Complete English words for programming and fault diagnostics; alphanumeric codes only are not acceptable
7. Time stamped fault history with details (amps, volts, type of fault etc.) of drive conditions of at least the last 3 faults with a timestamp and total history of at least 7 of the last faults
8. Displays and meters for the following: Output voltage, output frequency, motor rpm, motor current, motor watts, speed signal input, last three faults

F. Software Features
   1. Adjustable PWM switching carrier frequencies from 1 to 8 kHz.
      a. Include a PWM switching carrier frequency control circuit that reduces the carrier frequency based on actual VSD temperature that allows the highest PWM switching carrier frequency without derating the VSD or operating at high PWM switching carrier frequency only at low speeds.
   2. Ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable for each fault type.
   3. Ability to set a maximum current available to the motor with automatic speed reduction to prevent high current trip.
   4. Motor flux optimization that automatically reduces applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise.
   5. Noise smoothing feature that randomly varies switching frequency to distributes acoustic motor noise over a range of frequencies instead of a single tonal frequency resulting in lower noise intensity.
   6. Three programmable critical frequency lockout ranges to prevent the VSD from operating the load continuously at an unstable speed. Each lockout range must be fully adjustable from 0 to full speed.
   7. Adjustable acceleration and deceleration ramps, 1 – 1800 seconds adjustable.
   8. Fireman’s override logic
      a. May be applied to any programmable input
      b. Upon contact closure input, the VSD shall
         1) Operate in one of two modes:
            a) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward).
            b) Operate using internal PID loop that automatically adjusts motor speed based on programmable analog input and override set point.
         2) Ignore all serial communication and keypad commands
         3) Capable of being configured to ignore the run permissive contact (used for high static safeties, smoke detector, etc.) This mode shall be capable of being disabled during system testing to avoid damage.
         4) Capable of being configured to “run to destruct” ignoring all internal safeties that might prevent the VSD from operating at the preset speed. This mode shall be capable of being disabled during system testing to avoid damage.

G. Input/Outputs
   1. Minimum Inputs
      a. Two programmable analog inputs, 0/4-20ma or 0/2-10 Vdc signals, any of which shall be capable of being programmed to the following:
         1) Control point feedback signal for internal PID loop
         2) Control point setpoint for internal PID loop

b. Six programmable digital inputs, 24Vdc, any of which shall be capable of being programmed to the following:
    1) Start/stop
    2) Run permissive safety interlock
    3) Programmable preset speed
    4) Forward/reverse direction
2. Minimum Outputs
    a. Two programmable analog outputs, 0/4-20ma or 0/2-10 Vdc signals, any of which shall be capable of being programmed output proportional to the following:
        1) Motor Speed
        2) Motor Power (kW)
        3) Active PID Reference
        4) Active PID Feedback
    b. Three programmable, digital Form-C relay outputs, ≥8 amps at 24 VDC, any of which shall be capable of being programmed to the following:
        1) Open damper or VAV boxes with programmable time delay start
        2) Fan status, based on field adjustable motor current that can indicate broken belt or coupling
        3) Any fault/alarm
        4) Loss of input power to VSD

H. Controls
1. Self-contained controls
    a. Built-in PID control loop, allowing connection of a pressure or flow signal to a VSD analog input for closed loop control.
    b. A second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain the set point of an independent process.
    c. PID sleep feature to shut off VSD when speed drops below an adjustable value for an adjustable period of time.
    d. PID set points adjustable from the VSD keypad, analog inputs, or over the communications bus.
    e. Built-in time clock with a battery backup with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. VSD programming shall be held in non-volatile memory and is not dependent on battery power
2. Serial Communications
    a. Built in EIA-485 port with standard protocols
        1) BACnet-MS/TP
            a) Certified BTL listing as B-ASC
            b) Adjustable to 9.6, 19.2, 38.4, or 76.8 Kbps
    b. At a minimum, the following points shall be provided:
        1) Read only: Speed feedback, output speed, current, % torque, kW power, kilowatt hours (resettable), operating hours (resettable), drive temperature, digital input status, analog input values, all diagnostic warning and fault information, keypad “Hand” or “Auto” selected, bypass selected, deceleration rate, and acceleration rate
        2) Read/write: On/off, output speed, digital output status, analog output values, remote fault reset, PID setpoint and gains, maximum speed, and minimum speed

I. Bypass. Not required:

J. Enclosure
1. Enclosure requirements apply to VSD and all specified options and accessories.

2. VSD Enclosures shall be UL rated. Self-certified enclosures or enclosures with only NEMA ratings are not acceptable.
3. Provide enclosure scheduled on Drawings
    a. NEMA 1/UL Type 1 enclosure for indoor installation
    b. NEMA 3R/ UL Type 3R enclosure for outdoor installation
    c. NEMA 12/UL Type 12 for wet or dirty mechanical rooms
    d. NEMA 4X for outdoor installation in extreme climates
4. VSDs shall be UL listed as plenum rated where located in supply, return, or outdoor air stream.
5. NEMA 4X panel shall be stainless steel cabinet with temperature controlled mechanically cooled air isolated from outside air in the VSD cabinet.
6. Thermostatically controlled cooling fans shall be provided where required to meet ambient operating conditions. Fans shall be designed for replacement without requiring removal of the VSD from wall mount or removal of circuit boards. Fan sound power shall be no greater than local noise sources where VSD is installed. Fans shall operate only when required, based on the temperature and run command to the drive.

2.4 MOTOR CONTROLLERS

A. See Division 26 Electrical.

B. Refer to individual equipment sections for factory-provided controllers
    1. Installed on equipment by manufacturer
    2. Supplied with equipment by manufacturer for field installation

PART 3 EXECUTION

3.1 INSTALLATION

A. See Section 230548 Vibration and Seismic Control.

B. Coordinate with work of other trades.

C. Install in accordance with manufacturer's written installation instructions.

D. See 250000 Building Automation Systems for control wiring, including network interface wiring.

E. Drives for packaged equipment shall be mounted and wired by equipment manufacturer.

F. Mounting and power wiring of field mounted variable speed drives and other motor controllers is specified under Division 26 Electrical.
    1. Where wall space is not available for mounting VSDs or other motor controllers, provide mounting struts securely mounted to the floor, roof, or adjacent structure
    2. Strictly follow VSD manufacturer's recommendations, in particular with respect to grounding.

G. Set overload devices to suit motors provided in accordance with NEC.

3.2 INSPECTION

A. Verify that adequate clearance between motor, controllers and adjacent walls or equipment is available to permit maintenance and repairs.

B. Check that motor and controller are properly supported and allows for proper alignment and tension adjustments as necessary for application.

3.3 PRE-OPERATING CHECKS

A. Before operating motors and controllers
   1. See Section 230800 Mechanical Commissioning.
   2. Complete the Pre-Functional Test Data Sheet for each motor and controller.
   3. Check for proper and sufficient lubrication.
   4. Check for correct rotation.
   5. Confirm alignment and re-align if required.
   6. Check for proper adjustment of vibration isolation.

3.4 STARTUP, TESTING, AND ADJUSTING

A. Start and test motors and controllers in accordance with manufacturers written installation instructions.

B. After starting motors
   1. Check for high bearing temperatures.
   2. Check for motor overload by taking ampere reading at maximum operating conditions, with all valves open and individual motor running.
   3. Check for objectionable noise or vibration; correct as needed at no additional cost to the Owner.

C. Variable speed drives
   1. Certified factory start-up shall be provided. A certified start-up form shall be filled out for each VSD with a copy to the Owner's Representative and a copy kept on file by the manufacturer. Start-up technician shall configure the VSD as follows:
      a. Set variable speed ramp-up rates on variable air volume systems slow enough to prevent high pressure trips and/or damage to duct systems. Coordinate with Division 25 Building Automation Systems contractor.
      b. Set minimum speed for all applications in accordance with procedure indicated in Division 25 Building Automation Systems.
      c. Enable current limit control and set maximum current limit setpoint to the motor to the motor's full load amps.
      d. Enable flying start feature.
      e. Set voltage to speed ratio (V/f) to "squared"
      f. Enable Flux Optimization capability.
      g. Set switching frequency:
         1) Set to 4 kHz then check for motor noise in nearby occupiable spaces.
         2) If motor noise is audible in occupied space, enable noise smoothing feature.
         3) If noise is still a problem, raise switching frequency to 8 kHz. Do not raise switching frequency above 8 kHz.
      h. Configure status point to only indicate status when the drive detects a current above that which occurs when a belt is broken (fan), the rotor is locked, or a discharge damper or valve is fully closed.
      i. Set VSD to automatically restart with shortest time period allowed by VSD
         1) After power is restored after a power interruption
         2) After alarms are cleared

j. For fans such as relief fans and cooling tower fans: Run fan through entire speed range and program out speeds that cause fan vibration.
k. For VSDs powered by emergency generators, disable Under-volt Control (to cause the Pre-Charge Contactor to open as quickly as possible and prior to transfer of power, avoiding current surge and possible VFD damage).
l. For supply air fans for which supply air FSDs are interlocked to shut when the fan is off:
1) Configure one DO contact to close when the VFD has been commanded to start. (This is used to convey to the fire alarm system that the FSDs must be opened. All wiring by Division 26.)
2) Configure the VFD so the drive does not actually start until 15 seconds after the above DO contact has been closed. (This provides sufficient time for the fire alarm system to open the FSDs to avoid a nuisance trip.)

2. For VSDs used for life safety fans:
a. Configure programmable input(s) per Paragraph 2.3F.8 to speed determined under Section 230593 Testing, Adjusting, and Balancing. This input shall be connected to the Fire Alarm System by Division 26.
b. During smoke control system testing, disable safety ignore and run-to-destruct features described under Paragraphs 2.3F.8.b.3) and 2.3F.8.b.4). Once testing is fully complete and just prior to witness testing with AHJ, enable both features.
c. Configure one DO contact to open when power is not available per Paragraph 2.3G.2.b.4). This contact shall be connected to the Fire Alarm System by Division 26.
3. After VSD is fully configured and programmed, all settings shall be documented and included with commissioning documentation in electronic format per Section 230501 Basic Mechanical Materials and Methods. The intent is to allow replacement drive electronics to be readily configured.
4. See Section 250000 Building Automation Systems for points to be mapped from the drive controller to the BAS; coordinate information addresses and other information required with the Division 25 Building Automation Systems contractor.

D. See Section 230593 Testing, Adjusting and Balancing.

E. See Section 230800 Mechanical Commissioning.

3.5 TRAINING

A. See Section 230800 Mechanical Commissioning.

B. VSD manufacturer to provide one of the following:
1. 8-hours of customer training
2. Interactive Computer based training on VSD installation, start-up, programming, and trouble shooting

END OF SECTION

SECTION 230523

VALVES

PART 1 GENERAL

1.1 SUMMARY

A. Work Included in This Section: Materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Service valves in hydronic systems
   2. Check valves
   3. Pressure reducing valves
   4. Safety and relief valves
   5. Manual and automatic air vents
   6. Miscellaneous valves

1.2 QUALITY ASSURANCE

A. Provide valves with manufacturer's name and pressure rating clearly marked on outside of body.

1.3 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Valves, all types	R	R		R
Manual and automatic air vents	R2	R		

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Ball, butterfly, and check valves
   1. Nibco Inc.
   2. Crane Company
   3. De Zurik Corporation
   4. Victaulic
   5. Or equal

C. Silent check valves
   1. Nibco, Inc.
   2. Grinnell
   3. Mueller Steam Specialty
   4. Victaulic
   5. Or equal

D. Combination check and shut-off valves and Triple duty valves: Not allowed

E. Pressure relief valves
   1. ITT Bell and Gossett
   2. Watts
   3. Consolidated
   4. Tour & Anderson
   5. Or equal

F. Vent and cocks
   1. Weiss
   2. Weksler
   3. Crane Company
   4. Lunkenheimer
   5. Or equal

G. Automatic air vents
   1. Amtrol Inc.
   2. Bell and Gossett ITT
   3. Hoffman
   4. Or equal

2.2 GENERAL

A. Where possible, provide valves of same manufacturer for all Mechanical Sections per products in this Section.

B. For copper tubing provide solder-joint valves, flare fittings, or IPS-to-copper adaptor, sized for use with tubing and respective valve.

C. For flanged valves, provide streamline companion flanges, ANSI B16.5, 1988 150 class pounds per square inch
   1. 255 pounds per square inch at 150 degree Fahrenheit
   2. 225 pounds per square inch at 250 degree Fahrenheit unless indicated otherwise

D. Provide valves rated not less than 125 pounds per square inch steam working pressure, unless indicated otherwise.

E. Provide valve materials suitable for service and temperature of respective systems, especially with respect to discs, plugs, balls, linings, gaskets, and lubricants of plug cocks, ball valves, etc.

F. Provide chain-operated hand wheels, rustproof chain and chain guide for following valves
   1. Valves 8 feet or more above operating floor or platform
   2. As noted

G. Valves in Insulated Piping: With 2 inch stem extensions and the following features:
   1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation and memory stops that are fully adjustable after insulation is applied. Nibco Nib-seal handle extension or equal by Conbraco Industries, Inc. or Apollo Div.
   2. Butterfly Valves: With extended neck.

2.3 BUTTERFLY VALVES

A. Flange Type
   1. Cast Iron body
   2. 316 or 416 stainless steel stem, continuous with pinned disc
   3. Disk shall be either
      a. 304 or 316 stainless steel
      b. Aluminum bronze
      c. Nickel encapsulated ductile iron
      d. EPDM encapsulated ductile iron
      e. Nylon encapsulated ductile iron
   4. EPDM seat and seal
   5. Factory tested bubble-tight at 150 pounds per square inch

B. Type
   1. Lug Type
      a. Equal to Nibco Series LD-2000
      b. Lugs drilled and tapped to match ANSI 150 flanges
      c. Recommended by manufacturer or dead-end service at full pressure without the need for downstream flanges
      d. Use cap screws both sides
   2. Wafer Type
      a. Equal to Nibco Series WD-2000
   3. Grooved-end type
      a. Equal to Victaulic 300 MasterSeal
      b. Recommended by manufacturer or dead-end service at full pressure without the need for downstream flanges

C. Operator
   1. Throttling handle with memory stops: smaller than 8 inches
   2. Gear operators: 8 inches and larger

2.4 BALL VALVES

A. Materials
   1. Two piece body, bronze ASTM B584 C84400
   2. 316 stainless steel stem and ball
   3. PTFE Seat
   4. Full Port 1/2 to 1 inch; Standard Port 1-1/4 and larger
   5. 600 pounds per square inch at 100 degree F, 125 pounds per square inch saturated steam
   6. Infinite throttling handle with memory stop
   7. Equal to Nibco 580-70-66

B. Lock guard/shield
   1. Where called for on drawings

2. Equal to Brady Ball Valve Lockout (padlock by Owner)

2.5 MANUAL BALANCING VALVES

A. Not used

2.6 AUTOMATIC BALANCING VALVES

A. Not used

2.7 CHECK VALVES

A. Silent Check Valves
   1. For pump discharges:
      a. Variable speed pumps. Check valve pressure drop shall vary roughly as the square of flow rate to near zero flow. Valves that use hydrodynamic profiles (e.g. Victaulic 716 and 779 check valve) resulting in high or erratic pressure drop at low flow rates are not acceptable.
   2. 2 inches or smaller
      a. Bronze body
      b. Center-guided disk, silent check
      c. Class 125 (125 psi steam, 200 psi water)
      d. Bronze trim
      e. Buna-N disk
      f. Equal to Nibco 480
   3. 2-1/2 inches or larger
      a. Cast-Iron body
      b. Center-guided disk, silent check
      c. Class 125 (125 psi steam, 200 psi water)
      d. Bronze trim
      e. Bronze disk with Buna-N seat
      f. Flanged body or wafer style
      g. Equal to Nibco F-910 or W-910

2.8 SAFETY AND RELIEF VALVES

A. General
   1. Constructed, rated and stamped in accordance with Section IV of the ASME Boiler and Pressure Vessel
   2. Direct spring-loaded type
   3. Adjustable discharge pressure setting
   4. Brass or bronze body and all wetted parts shall be non-ferrous
   5. Suitable and rated for system pressure and temperature

B. Set pressures
   1. Set pressure as indicated on Drawings; not to exceed pressure rating of protected equipment
   2. Valves to open, under test, at set pressure with following tolerance
      a. Set pressure up to 70 pounds per square inch gage: plus or minus 2 pounds per square inch
      b. Set pressure, above 70 pounds per square inch gage: plus or minus 3 percent

C. Capacities
   1. Valves shall have capacity to relieve maximum possible generated energy while maintaining pressure in protected equipment at no more than 10 percent above vessel working pressure.
   2. Provide multiple valves if required for capacity even though only one valve may be shown on Drawings

2.9 VENT & GAUGE COCKS

A. Bronze body, 1/4 inch size

B. Lever handle

C. 125 pounds per square inch steam working pressure

D. Equal to Weiss LC-14

2.10 AIR VENTS

A. Manual Air Vents
   1. Vertical
   2. Provide 1/4 inch brass needle or ball valve at top of chamber
   3. To 3 inch pipe: Line size air chamber, 12 inch long
   4. 4 inch to 8 inch: Line size air chamber, 6 inch long
   5. 10 inch and larger: Line size pipe cap

B. Automatic Air Vents
   1. Float type
      a. With isolating valve
      b. Brass or cast iron body
      c. Copper or stainless steel float
      d. Stainless steel valve and valve seat
      e. Suitable for system operating temperature and pressure
      f. Non-opening on negative pressure
      g. Equal to Amtrol No. 747
   2. Threaded vent connection for piping vent to drain
   3. Upstream valve cock for isolation

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install valves in accordance with manufacturer’s written installation instructions.

C. Provide valves as shown on drawings.
   1. Ball and butterfly valves are considered interchangeable; where one type is shown on drawings, the other type may be used at contractor’s option.

D. Provide all valves (except control valves), strainers, and check valves of same size as the pipes in which they are installed unless otherwise indicated.

E. Pressure rating of valves same as piping in which installed.

F. Install valves with stems upright or horizontal, not inverted.

G. Install valves with cast directional arrows in direction of flow.

H. Support line valves at the valve in addition to regularly spaced pipe supports shown and specified.

I. Check valves
   1. Provide silent check valves at discharge of pumps. Triple duty valves shall not be used as a substitution for check and shut-off valve.
   2. Install swing checks and gravity closing lift checks in horizontal position.
   3. Provide straight pipe upstream of valve after pump discharge or elbows as recommended by the valve manufacturer.

J. Butterfly valves
   1. Lug or Grooved-end type at equipment isolation valves and for capped dead head shut off only. Piping adjacent to lug type shall be flange removable while valve is in use.
   2. Lug, wafer or Grooved-end type at all other locations

K. Control valves
   1. See Section 250000 Building Automation System for valve specifications.
   2. Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where the actuator top and position indicator are below 5 feet above the floor, install with valve stem axis vertical with actuator side up. Otherwise, valves shall be installed with stem horizontal so that the position indicator is visible from the floor. Do not install valves with stem below horizontal or down.

L. Provide blow-down ball valves and hose adaptors at strainers, air separators, tanks, pipe traps, equipment drains, etc. of same size as strainer blow-off connection.

M. Provide drain valves at main shut-off valves, low points of piping and apparatus.

N. Locate wheel handles to clear obstructions with hand.

O. Install valves only in accessible locations.

P. Wherever possible, install valves accessible from floor level. Provide guided chain operators on valves over 8 feet above floor in equipment areas. Extend chains to within 6 feet 6 inches of floor.

Q. Locate equipment shut-off valves to be accessible without climbing over equipment.

R. Provide operating handles for all valves and cocks without integral operators, unless otherwise noted. Provide adequate clearance for easy operation.

S. Provide discharge pipe to atmosphere from all relief and safety valves, sized with area equal to sum of outlet areas of all valves connected thereto, unless indicated larger. Extend to over code compliant drain receptacle with air gap.

T. Provide open-ended line valves with plugs or blind flanges.

3.2 AIR VENTS

A. Manual air vents
   1. Locate
      a. As shown on drawings
      b. At all high points in closed piping systems
      c. At equipment with vents, such as coils
   2. 1/4 inch copper tube discharged into nearest drain or with 180 degree bend to discharge into portable container
   3. Extend tubing or piping as required to make valve accessible

B. Automatic air vents
   1. Locate as shown on drawings.
   2. Provide manual cock at inlet to automatic air vents. Except for vent on air separators, shut valve after system is free of air (to prevent leaks from failed floats).
   3. 1/4 inch copper tube discharged into nearest drain

3.3 FIELD QUALITY CONTROL

A. Test operate valves from closed-to-open-to-closed position while valve is under test pressure.

B. Test automatic valves including solenoid valves, expansion valves, water regulating valves, pressure reducing valves, pressure relief valves, safety valves and temperature and pressure relief valves for proper operation at settings indicated.

C. Insure that valves are field checked for packing and lubricant and that disc is for service intended. Replace leaking packing at no additional cost to the Owner. Service valves which do not operate smoothly and properly with suitable lubricant before placing in operation at no additional cost to the Owner.

3.4 INSPECTION & COMPLETION

A. Verify that adequate clearance between valves and adjacent walls or equipment is available to permit maintenance and repairs.

B. Verify valve set for normal operation.

C. Valves tags: See Section 230553 Mechanical Identification.

D. See Section 230800 Mechanical Commissioning.

E. See Section 230593 Testing, Adjusting and Balancing.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230529

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Pipe and duct hangers, supports and associated anchors
   2. Thermal hanger shields for insulated piping

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers: ASME Section VIII – Boiler and Pressure Vessel Code – Pressure Vessels

B. Pipe Supports: ANSI B31.9, Facility Services Piping

C. Duct Hangers: SMACNA Duct Manuals

1.3 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Pipe hangers and supports	R2			R
Structural attachments	R2			R
Pipe protection and thermal hanger shields	R2			
Expansion shields	R2			

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Hangers, Inserts and Supports
   1. Midland-Ross Corp.: Superstrut
   2. Elcen Metal Products Company

3. Fee and Mason
4. ITT Grinnell Corporation
5. Kin-Line, Inc.
6. Unistrut
7. Superstrut
8. B-Line
9. Tolco
10. Mason Industries
11. Or equal

C. Pipe Protection and Thermal Hanger Shields
1. Pipe Shields, Inc.
2. Elcen Metal Products Company
3. Midland-Ross Corp.: Superstrut
4. Uni-Grip
5. Kin Line
6. Or equal

D. Expansion Shields
1. ITT Phillips Drill Co.: Red Head
2. Hilti Fastening Systems
3. Omark Industries, Inc.
4. Ramset Fastening Systems
5. Or equal

2.2 PIPE HANGERS AND SUPPORTS

A. Model numbers are Superstrut, unless otherwise indicated. Equal products from all other manufacturers are acceptable.

B. Provide electro-chromate, galvanized or factory painted finish; no plain "black" hangers allowed

C. Dielectric Isolators: All uninsulated copper tubing systems; Superstrut isolators or equal, Cush-A-Strip or Cush-A-Clamp on all pipe clamps; for individual hangers, use felt lined hangers

D. Individual Pipe Hangers
1. Cold pipe all sizes: Clevis hanger, No. C710
2. Hot pipe sizes up to 4 in: Clevis hanger, No. C710
3. Hot pipe sizes above 6 in: Adjustable steel yoke and cast iron roll No. C729

E. Multiple or Trapeze Hangers
1. Factory channel
   a. 12 gauge thick steel
   b. Single or double section
   c. Electro-chromate finish
   d. Strutnuts: Series A-100 or CM-100
   e. Straps: Series 702
   f. Other accessories
   g. No. A-1200 or A-1202
2. Hot pipe sizes 6 in and larger: cast iron roll and stand; C728 or CR728

F. Wall Supports
1. Pipe sizes up to 3 in: Steel bracket No. C738

2. Pipe sizes 4 in and larger: Welded steel bracket C-735
3. Hot pipe sizes 6 inches and larger
   a. Welded steel bracket No. C739
   b. Adjustable steel yoke and cast iron roller No. C729

G. Vertical Support
1. General: Riser clamp Series C-720
2. Chilled water: Either of the following:
   a. Hydra-Zorb (copper) or Pipe Shield (steel)
   b. Series C-720 wrapped with insulating tape.

H. Floor Support:
1. Hot pipe sizes up to 4 in; cold pipe, all sizes
   a. Adjustable cast iron saddle No. R786
   b. Locknut nipple
   c. Floor flange
2. Hot pipe sizes 6 in and larger: Adjustable cast iron roll and stand No. R-730-C

I. Thermal Hanger Shields
1. High density insert
   a. See Section 230700 Mechanical Insulation
   b. Same thickness as adjoining pipe insulation
2. Galvanized sheet metal shield
   a. Shield length and gauges

Pipe Size	Shield Length	Minimum Gauge
1/2-1 1/2	4	26
2 - 6	6	20
8 - 10	9	16

3. Insert to extend one inch beyond metal shield ends on chilled water piping
4. Use double layer shield on bearing surface for
   a. Roller hangers
   b. Support spacing exceeding 10 feet
5. Pipe Shields Incorporated or equal

J. Pipe Isolators
1. Hanger with minimum ¼ inch felt padding
2. Tolco Fig. 3F felt lined hangers or equal

K. Insulated Pipe Supports
1. Pipe supported on rod hangers - use Models A1000, A2000, A3000, 4000 and A9000
2. Pipe supported on flat surfaces - use Models A1000, A2000, A5000, A6000, A7000, A7200 and A7400 Series
3. Pipe supported on pipe rolls - use Models A3000, A4000, A5000, A6000, A8000, A8200 and A8400 Series
4. Model designations are Pipe Shields, Inc. or equal; use only models designed for service for which supports are to be used

L. Anchors and Guides: Provide anchors and guides where indicated on the Drawings and as required. Structural inserts shall be high density calcium silicate compressive strength 600 pounds per square inch. Guide slide pads shall be Teflon. Ensure that slide accommodates pipe movement over full range of service and out-of-service temperatures. Guides shall be Pipe Shields, Inc. Model #B3000 or equal. Anchors shall be Pipe Shields, Inc. Model #C4000 or equal. See Section 230700 Mechanical Insulation.

M. Insulated Pipe Strap
   1. 1/2 in to 1 in plumbing piping in wood frame construction
   2. Felt insulated
   3. Nailable pipe straps; In lieu of other hangers and dielectric isolators
   4. Kopty or equal

N. Escutcheons: See Section 232114 Piping Specialties

O. Flashing and Sleeves
   1. Flashings
      a. See Division 7 Thermal and Moisture Protection
      b. Flash and counter flash watertight all pipe and duct penetrations of roofs and exterior walls
      c. Flash pipes through roofs with ITWBuildex Dektite
      d. Flash vents through roofs with
         1) Minimum 24 gage soldered roof jack for flat surface roofs
         2) Minimum 4 pound lead soldered roof jack for roofs other than flat surface roofs
         3) Vandal caps
         4) Provide counter-flashing sleeves and storm collars
         5) Caulk counter-flashing and storm collar weather tight
         6) Other flashings shall be minimum 24-gage galvanized sheet metal
   2. Sleeves
      a. Through exterior concrete walls below grade, floor slabs on grade, and through concrete tank walls
         1) Schedule 40, galvanized steel pipe sleeves
         2) Seal annular space between pipe and sleeve water tight with one of the following
            a) Thunderline Link-Seals
            b) Calpico Pipe Linx
            c) Or equal
      b. Other concrete walls, floors and roofs
         1) Adjustable telescopic metal sleeves
         2) Tightly pack annular space between pipe and sleeve with fiberglass. Seal both sides with mastic
      c. For insulated piping, sleeve diameter shall not be less than diameter of insulation.
      d. Terminate sleeves flush with walls, and ceiling.
      e. For flood prevention on vertical pipe, extend sleeves 1 inch above finished floor or use W-rated waterproof fire barrier packing.
      f. Firestopping at penetrations of fire rated floors and partitions. See Section 232113 HVAC Piping.
   3. Separate piping through walls, other than concrete walls, from contact with wall construction materials; use non-hardening caulking.
   4. Install insulation on piping in walls which require insulation at time of installation.

2.3 DUCT HANGERS AND SUPPORTS

A. See Section 233100 Ducts

2.4 STRUCTURAL ATTACHMENTS

A. Model Numbers are Superstrut, unless otherwise indicated

B. Anchor Bolts: Size as specified for hanger rods

C. Concrete Inserts
   1. Malleable iron
   2. Place reinforcing steel through insert as recommended by manufacturer for recommended loads
   3. No. 452 or equal

D. Beam Clamps
   1. All with U-568 safety strap
   2. All with locknuts on
      a. Set Screw
      b. Hanger rod
   3. Bottom flange attachment
      a. Loading 150 pound and less: U-563
      b. Loading 150 pound to 300 pound: U-562
      c. Loading more than 300 pound: U-560
   4. Top flange attachment
      a. Permitted only when bottom flange attachment cannot be used
      b. Loading 400 pound and less: M-777
      c. Loading more than 400 pound: M-778

E. Welded Beam Attachments
   1. No. C-780 or equal

F. Side Beam Brackets
   1. No. 542 or equal

G. Hanger Rods
   1. ASTM A575 Hot rolled steel
   2. ANSI B1.1 Unified Inch Screw Treads
   3. Threaded both ends, threaded one end, or continuous threaded

H. Hanger Rod Fixtures
   1. Turnbuckles: No. F-112 or equal
   2. Linked Eye Rod
      a. Rod swivel
      b. No. E-131 or equal
   3. Clevis: No. F-111 or equal

I. Powder or Gas Actuated Anchors
   1. Hardened steel stud with threaded shank; size of shank to match hanger rod size
   2. Use only with non-shock loads
   3. Maximum load safety factors:
      a. Maximum anchor load: 100 pounds
      b. Static loads - 5
      c. Vibratory loads - 8-10
   4. For concrete and steel; not to be used for light weight concrete, brick or concrete block
   5. 10% testing rate required, testing by contractor
   6. Omark Drivit or equal

J. Expansion Shields
   1. Carbon-steel anchors, zinc coated
   2. Stainless steel for corrosive atmospheres
   3. For normal concrete use
      a. Self-drilling anchor
      b. Sleeve anchor

c. Stud anchor
4. For thin concrete use: wedge anchor
5. For brick or concrete block use: sleeve anchor
6. Maximum load safety factors
   a. Static loads - 4
   b. Vibratory loads - 8 - 10
   c. Shock loads - 8 - 10
7. Size to suit hanger rods
8. ITT Phillips Red Head or equal

K. Steel Deck Inserts
1. Factory stud with
   a. Clip
   b. Spring
   c. Coupling
2. ITT Phillips Red-Head or equal

L. Miscellaneous Metal
1. Steel plate, shapes and bars: ASTM A36
2. Steel pipe columns: ASTM A53, Schedule 40, black
3. Bolts and nuts: regular hexagon-head type, ASTM A307, Grade A
4. Lag bolts: square head type, Fed. Spec. FF-B-561
5. Plain washers: round, carbon steel, Fed. Spec. FF-W.92

PART 3 EXECUTION

3.1 PIPE HANGERS, SUPPORTS AND GUIDES

A. General
1. Assure adequate support for pipe and contents
2. Provide adjustable hangers for all pipes complete with inserts, adjusters, bolts, nuts, swivels, all-thread rods, etc., except where specified otherwise
3. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping and do not support piping from other piping.
4. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping
5. Install all cast iron piping in accordance with Cast Iron Soil Pipe Industry (CISPI) Standards
6. Support all piping within 2 feet of each change of direction on both sides of fitting
7. Thermal hanger shields shall be provided at hangers and supports where piping is insulated
8. Prevent vibration or swaying
9. Provide for expansion and contraction
10. Supports of wire, rope, wood, chain, strap perforated bar or any other makeshift device not permitted
11. Comply with applicable requirements at ANSI B31.1 and B31.2 for piping
12. Support piping independently so that equipment is not stressed by piping weight of expansion
13. See Section 230548 Vibration and Seismic Control for mechanical sound, vibration, and seismic control
14. See Section 230548 Vibration and Seismic Control for hangers, guides, anchors and supports requiring vibration isolation units

15. Hangers and supports shall have minimum safety factor of five (5), based on ultimate tensile or compressive strength, as applicable, of material used; base calculations on equipment's heaviest operating weight and pipes full of water
16. Install additional supports or braces if, during normal operation, piping should sway, crawl or vibrate. Piping shall be immobile
17. Install thrust blocks as required to prevent sway

B. Horizontal piping, except as noted
1. Adjustable clevis type and rod; all services at or below 250 degrees F
2. Rollers or slide bases: not required
3. Trapeze hangers; guide individual pipes on trapezes with 1/4 inch U-bolt or Superstrut 702 pipe clamp
   a. Install thermal hanger shield at each support point
4. Galvanized sheet metal shields between hangers and PVC piping
5. Threaded steel rods
   a. 2 in vertical adjustment with 2 nuts each end for positioning and locking
   b. Size to 12 in inside pipe size (IPS)

Pipe, IPS	Rod
to 2 inch	3/8 inch
2-1/2 inch and 3 inch	1/2 inch
4 inch	5/8 inch
6 inch and 8 inch	3/4 inch
10 inch and 12 inch	7/8 inch

   c. Size above 12 inch IPS and multiple pipe standards: safety factor of 5 on ultimate strength on area
   d. For double rod hangers: 1 size smaller than above

C. Vertical piping
1. Base support
   a. Base elbow or welded equivalent
   b. Bearing plate on structural support
2. Guides
   a. At every third floor but not to exceed
      1) 25 feet for piping to 2 inch
      2) 36 feet for piping 2-1/2 inch to 12 inch
      3) 50 feet for piping 14 inch and larger
   b. Or as otherwise designed by the Vibration Isolation vendor; coordinate with Section 230548 Vibration and Seismic Control
3. Top support
   a. Special hanger or saddle in horizontal connection
   b. Provisions for expansion
4. Intermediate supports: steel pipe clamp at floor
   a. Bolted and welded to pipe
   b. Extension ends bearing on structural steel or bearing plates
5. For multiple pipes: coordinate guides, bearing plates and accessory steel

D. Horizontal insulated piping
1. Install saddles for rollers or slide bases
2. Install thermal hanger shields for all other types of supports
3. See Section 230700 Mechanical Insulation for insulation connection to shields

E. Vertical insulated piping

1. Install thermal hanger shields at guides
2. Use insulated riser clamps at rigid connections.
3. See Section 230700 Mechanical Insulation for insulation connection to shields

F. Install Pipe Isolators between hangers and piping for all uninsulated copper tubing.

G. Spring Supports for Piping
1. See Section 230548 Vibration and Seismic Control

H. Miscellaneous Steel
1. Provide miscellaneous steel members, beams, brackets, etc., for support of work in this division unless specifically included in other divisions

I. Fire-stopping
1. At pipe penetrations through rated assemblies
2. Commercial pipe sleeve assemblies that are UL listed and that have been approved by the fire marshal for this purpose.

3.2 PIPE SUPPORT SPACING

A. Maximum spacing for horizontal piping

Type of Pipe	Size	Maximum Spacing
Steel	1-1/2 inch and smaller	7 feet
	2 inch and larger	10 feet
Copper	3/4 inch and smaller	5 feet
	1- 1-1/2 inch	6 feet
	2 - 3 inch	8 feet
	4 inch and larger	10 feet
Plastic	3/4 inch and smaller	3 feet

B. Spacing Notes: Additional supports at
1. Changes in direction
2. Branch piping and runouts over 5 feet
3. Concentrated loads due to valves, strainers and other similar items
4. At valves 4 inch and larger in horizontal piping, support piping on each side of valve

C. Parallel piping on trapezes
1. Maximum spacing to be that of pipe requiring closest spacing

3.3 ATTACHMENT TO STRUCTURE

A. Concrete
1. Use inserts for suspending hangers from reinforced concrete slabs, walls and sides of reinforced concrete beams wherever practicable
2. Set inserts in position in advance of concrete work
3. Provide reinforcement rod in concrete for inserts carrying
   a. Pipe over 4 inch
   b. Ducts over 60 inches wide
4. Where concrete slabs form finished ceiling, finish inserts flush with slab surface
5. Where inserts are omitted, install hangers with expansion shields
6. Through-deck support

a. Drill through concrete slab from below
b. Provide rod with recessed square steel plate and nut above slab

7. Powder actuated anchors or expansion shields may be used in lieu of inserts
   a. In bottom of thick slabs
   b. In thin slab construction, only in sides of beams
8. Pre-Cast Concrete
   a. Use pre-set inserts
   b. Where inserts are not available, field drill through beam or joists at locations as directed by Owner's Representative
   c. Through bolt side beam bracket to beam or joist
9. Poured-In-Place Concrete
   a. With metal form or underdeck
   b. Before concrete is poured
      1) Field drill hole through metal deck
      2) Provide bearing plate, nut and locknut on rod; or install factory-made steel deck inserts specified hereinbefore
   c. After concrete is poured
      1) Install hangers with expansion shields

B. Steel Beam Anchors
1. Beam or channel clamps
2. Do not cut or weld to structural steel without permission of structural engineer

C. Steel Deck Anchors
1. Concrete filled: as specified above
2. Decking without concrete
   a. Through rod Support
      1) Weld to square plate, 1/4 in thick
      2) Plate to distribute load over minimum of two full cells
      3) Coordinate with floor layouts to clear cells with wiring

D. Side Wall Supports
1. Concrete walls
   a. As specified for hangers
2. Stud Walls
   a. Toggle bolts
   b. Studs welded to structural studs

E. Support Spreaders
1. Install spreaders spanning between structural members when hangers fall between them, and hanger load is too great for slab or deck attachment
2. Spreaders may be one of methods listed below, or combination of both as required
   a. Fabricated from structural channel
      1) End fittings bolted or welded
      2) Secure to structural members
         a) As required by construction
         b) As reviewed by Structural Engineer
   b. Formed channels with fittings, Superstrut or equal
      1) Submit manufacturer's calculations for installation

3.4 DUCT HANGERS AND SUPPORTS

A. See Section 233100 Ducts

END OF SECTION

SECTION 230548

VIBRATION AND SEISMIC CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Work Included in This Section: Materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Vibration isolators for equipment
   2. Vibration isolators for piping systems
   3. Equipment bases
   4. Inertia bases
   5. Seismic control for equipment on isolators
   6. Seismic bracing and restraints for piping and ductwork
   7. Seismic bracing and restraints for rigidly mounted equipment
   8. Seismic bracing and restraints for flues

1.2 REFERENCE STANDARDS

A. ASHRAE – American Society of Heating, Refrigerating and Air Conditioning Engineers

B. NEMA – National Electrical Manufacturer's Association

C. Underwriters' Laboratories, Inc.: UL 778 – Motor Operated Water Pumps

D. American Society of Mechanical Engineers: ASME Section VIII – Boiler and Pressure Vessel Code – Pressure Vessels

E. Published specifications standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this section where cited below
   1. Mason Industries “Seismic Restraint Guidelines for Suspended Piping, Ductwork, and Electrical Systems”
   2. SMACNA and PPIC “Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems”.

F. Publication references below are basic industry standards; however, regulatory requirements may reference, modify or supersede:
   1. American Institute of Steel Construction (AISC) publications
      a. Specification for the Design, Fabrication and Erection of Structural Steel Buildings (Eighth Edition)
   2. American National Standards Institute (ANSI) Standard
      a. B027.2-965 – Plain Washers
   3. American Society for Testing and Materials (ASTM) Specifications
      a. A 6 – General Requirements for Delivery and Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use
      b. A 36 – Structural Steel
      c. A 53 – Welded and Seamless Steel Pipe
      d. B633 – Electrodeposited Coatings of Zinc on Steel

e. A 307 – Carbon Steel Externally and Internally Threaded Standard Fasteners
f. A 500 – Cold-Formed Welded and Seamless Carbon Steel Structural Tubing
g. A1011 – Hot Rolled Carbon Steel Sheet and Strip

4. American Welding Society (AWS) Publication
   a. D 1.1 – Structural Welding Code

1.3 QUALITY ASSURANCE

A. Qualifications
   1. Manufacturer
      a. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture for not less than five years

B. Manufacturer or manufacturer's representative of vibration isolation equipment shall have the following responsibilities
   1. Determine vibration isolator sizes and locations
   2. Provide piping and equipment isolation systems as scheduled or specified
   3. Guarantee specified isolation system static deflection under installed actual load.
   4. Provide installation instructions, drawings and field supervision to assure proper installation, adjustment and performance

C. The installation of all vibration isolation units and associated hangers and bases shall be as directed by the vibration isolation manufacturer's representative.

D. It is the objective of this Specification to provide the necessary design for the control of excessive noise and vibration in the building due to the operation of machinery or equipment, and due to interconnected piping, ductwork or conduit
   1. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.
   2. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50 percent greater than the design deflection.
   3. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than ±10 percent.
   4. All neoprene mountings shall have a Shore hardness of 30 to 50 ±5, after minimum aging of 20 days or corresponding oven-aging.

E. Acoustical Testing
   1. The contractor shall cooperate with regard to sound tests (ARI 575, ANSI S1.13) which may be conducted by the Owner’s Representative to verify that noise criteria are met.
   2. The contractor shall notify the Owner’s Representative of any changes which will affect the acoustical performance.

F. Seismic load calculations for piping, ductwork and equipment
   1. Fp, the total design lateral seismic force, shall be calculated by a licensed structural engineer, unless it is explicitly stated in the plans or specifications. This engineer shall be hired by the contractor responsible for this Section of work.
   2. Shall meet California Building Code requirements
   3. Calculations required for supports and bracing for situations not covered by referenced Guidelines.
      a. Hired by contractor under this Section or work

b. Cost of calculations borne by contractor under this Section

4. Calculations made and signed by registered civil or structural engineer knowledgeable in seismic design
5. Include horizontal and vertical reaction loads at connections to building structures for all seismic restraints, including those covered by referenced Standards
   a. Coordinate reaction loads and attachment details with structural engineer for building

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Vibration isolation devices: catalog cuts, static deflections, quantity, load per isolator, mounting details, seismic restraints, mounting details, etc.	R	R		
Concrete and steel details for equipment pads.				R
Welds or anchor bolt locations.				R
Reinforcing and template steel locations and details				R
Seismic calculations for each seismic restraint sized and signed by registered structural or civil engineer.	R	R		
Inertia and equipment bases	R	R		R
Anchors, inserts and fasteners and fastening details	R2	R2		R
Seismic restraints	R2	R2		R
Seismic bracing and restraint mounting details	R	R		
Flexible pipe connectors	R	R		R
Flexible duct connectors	R2	R2		R

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Vibration Isolation
   1. Mason Industries, Inc.
   2. Kinetics Noise Control, Inc.
   3. M.L. Saussé & Co. (Vibrex)
   4. Amber-Booth
   5. Or equal.

C. Flexible Duct Connections
   1. Ventfabrics
   2. Duro Dyne
   3. Or equal

D. Seismic Restraints
1. Hangers and snubbers: Any manufacturer who can verify compliance with SMACNA standards and the California Building Code
2. Strut - Channel Framing: Any manufacturer who can verify compliance with SMACNA standards and the California Building Code
3. Anchors - Drill in, wedge type: Any manufacturer who can verify compliance with the California Building Code
4. Snubbers: Any manufacturer who can verify compliance with the California Building Code

2.2 VIBRATION ISOLATOR TYPES

A. Spring type
1. Spring isolators shall incorporate following
a. All springs to be single coil steel with minimum spring coil outer diameter 0.8 of loaded operating height
b. Horizontal spring stiffness within 0.8 to 1.25 times rated vertical spring stiffness
c. Corrosion resistance
1) Where exposed to corrosive environment including but not limited to:
a) Outdoors
b) Exposed to outdoor air within 5 feet of outdoor air intake
2) All metal parts hot dip galvanized unless noted otherwise
d. Reserve deflection (from loaded to solid height) of 50 percent of rated deflection
e. Designed and installed so that ends of springs remain parallel; neoprene cups not acceptable
f. Noise pads of ½ inch or 1 inch thickness below the spring base or within the frame to reduce the chance that the springs shall be resonant with equipment forcing frequencies or support structure natural frequencies. For seismic isolators, the pad shall be within the frame. See Table in Paragraph 3.4A.8 for applicability and thickness.
g. Leveling device
h. Where operating weight differs from installed weight provide built-in adjustable limit stops to prevent equipment rising when weight is removed. Stops shall not be in contact during normal operation.
2. Type "A": Similar to Mason Type SLF
3. Type "B": same as Type "A" except
a. Provide built-in resilient vertical limit stops
b. Tapped holes in top plate for bolting to equipment
c. Capable of supporting equipment at fixed elevation during equipment erection
d. Mason Type SLRSO or equal for 1 inch and 2 inch deflection, Type SLR Series 100 for 3 inch to 5 inch deflection
4. Type "C": spring hanger rod isolators shall incorporate the following
a. Spring element seated on steel washer within neoprene cup
b. Steel retainer box encasing spring and neoprene cup
c. Minimum 1/2 inch clearance between retainer box and spring hanger rod
d. Minimum 15 degrees angular clearance between rod and retainer box
e. Double deflection LDS element
f. Mason RW30N or equal

B. Elastomer mounting types
1. Type "D": Double deflecting type incorporating following
a. Bolt holes for bolting to equipment base
b. Bottom steel plates for bolting to sub-base as required
c. Unit type design molded in black oil-resistant neoprene
d. Neoprene compounded to meet following:
1) Not greater than 50 durometer

2) Minimum tensile strength 2000 pounds per square inch
3) Minimum elongation 300 percent
4) Maximum compression set of 25 percent of the original deflection

e. Mason Type ND or equal (where seismic restraint not required by CBC)
f. Mason Type BR or equal (where seismic restraint required by CBC)

2. Type "E": Elastomer hanger rod isolators shall incorporate following
   a. Molded unit type neoprene element
   b. Compounding described in Type "D" above
   c. Steel retainer box encasing neoprene mounting.
   d. Minimum 1/2 inch box
   e. Mason Type HD or equal
3. Type "F": Pad type elastomer mountings to incorporate following
   a. 5/16 to 3/8 inch minimum thickness per layer
   b. 50 psi maximum loading
   c. Ribbed or waffled design
   d. 1/16 inch galvanized steel plate between multiple layers of pad thickness
   e. 1/16 inch deflection per pad thickness
   f. Suitable bearing plate to distribute load
   g. Bolts through equipment and pad shall be oversized and provided with resilient washers, bushings and lock nuts
   h. Mason Type Super W Series or equal
4. Type "G": Pad type elastomer mountings to incorporate following
   a. High quality bridge bearing neoprene
   b. Maximum loading 800 psi
   c. Suitable bearing plate to distribute load
   d. Minimum thickness 2 inch
   e. Mason Type BBP or equal
5. Type "H": Combination spring/elastomer hanger rod isolators to incorporate following
   a. Spring and neoprene isolator elements in steel box retainer
   b. Characteristics of spring and neoprene as described in Type "C" and Type "E" hanger isolators
   c. Factory preloading to 75 percent of rated load
   d. Mason PC30N or equal

C. Seismic Snubbers
1. Type SS: All-directional seismic snubber
2. Neoprene bushing to be bridge bearing quality
3. Male portion to be smooth round bar; threaded bolts not acceptable
4. Mason Z-1225 or equal

2.3 EQUIPMENT BASES

A. Integral structural steel bases, Type "B-1"
1. Reinforced as required to prevent base flexure at start-up and misalignment of drive and driven units
2. Fan bases complete with motor slide rails
3. Drilled for drive and driven unit mounting template
4. Mason Type WFSL/WFND or equal

B. Concrete inertia base, Type "B-2"
1. Formed in structural steel frame
2. Structural base reinforced as required to prevent flexure, misalignment of drive and driven unit or stress transferal into equipment

3. Minimum thickness of the inertia base shall be 6 inches or greater if required to meet weight ratio specified below
4. Fan bases complete with motor slide rails
5. Pump bases shall be large enough to support suction and discharge elbows and suction diffusers
6. Bases complete with
    a. Height saving brackets
    b. Reinforcing
    c. Equipment bolting provisions
    d. Isolators provided by vibration control supplier, type as scheduled
7. Base ready for concrete pour
8. Inertia Base Weights
    a. Centrifugal Fans, except as noted: Minimum 1.0 times weight of fan, motor and drive
    b. Air handling Units, except as noted: Minimum 1.0 times weight of fan and coil cabinet, coils, fan, motor and drive
    c. Pumps: Minimum 1.5 times weight of pump, motor and base
        1) Base to be sized to support suction diffuser when used
9. Mason Type KSL/BMK or equal

C. Seismic restraint, Type I
1. All directional type
2. Steel and elastomeric
3. Mason Type Z-1225 or equal

D. Seismic restraint, Type II
1. Criteria
    a. Designed for seismic force criteria specified in Part 3
    b. Submit application details for approval

2.4 ANCHORS, INSERTS AND FASTENERS

A. All anchors and inserts shall be installed according to the California Building Code.

B. Do not use any anchor or insert in concrete which does not have a signed structurally engineered design value based on its installed application and one of the following
1. California Building Code evaluation report
2. Lab test report verifying compliance

C. Do not use powder driven and power driven (Shoot-In) fasteners, expansion nails or friction spring clips.

D. All over-head concrete anchors or inserts shall be selected to comply with the California Building Code table for the anchor or insert.

E. Torque testing of anchors shall be allowed to verify compliance of anchor installation. However, torque testing shall not justify usability of anchor. Only load or pull testing shall be allowed to justify usability of anchors. Failure of torque shall constitute failure of anchor.

F. Bolts and nuts
1. Bolts and heavy hexagon nuts: ANSI B18.2.1 and ASTM A307 or A576
2. Bolts, underground: ASTM A325
3. Expansion anchors: Federal Specification A-A-1922

2.5 SEISMIC RESTRAINTS

A. General
   1. Capable of safely accepting indicated external forces without failure
   2. Maintain equipment, piping and ducts in a captive position

B. Criteria: Design for seismic forces specified herein

C. Bracing system: Provide one of the following methods as most applicable for each brace
   1. Material used, except for pipes, shall be structural steel with ASTM A36. Steel pipes shall conform to ASTM A501
   2. Complete system of factory fabricated components
   3. Complete system of job fabricated components
   4. Miscellaneous metal structural shapes

2.6 FLEXIBLE PIPE CONNECTORS

A. Flexible Piping Couplings for Vibration Isolation
   1. Flexible mechanical joints
   2. Victaulic Style 077/177 or equal

B. Twin Sphere Connections for Vibration Isolation
   1. Molded twin-sphere type connectors made of peroxide cured EPDM and Kevlar tire cord reinforcement and reinforcing ring
   2. Connectors up to 2 inch diameter may have threaded ends
   3. Connectors 2-1/2 inch diameter and larger to have floating steel flanges recessed to lock the connector's neoprene flanges
   4. Connectors rated a minimum of 150 pounds per square inch at 220 degrees Fahrenheit without control rods or cables; connectors that require control rods are not acceptable.
   5. Mason SAFEFLEX Type SFDEJ (no equal)

2.7 FLEXIBLE DUCT CONNECTORS

A. General
   1. Conform to NFPA 701 and NFPA 90A
   2. Flame spread rating: 25
   3. Smoke development rating: 50
   4. Airtight and waterproof to plus or minus 10 inches

B. Construction
   1. Metal collar at each end
      a. Galvanized steel G60
      b. Minimum thickness: No. 24 USSG
      c. Minimum length: 3”
      d. Double lock joint
   2. Length of fabric
      a. Minimum: 4 inch
      b. Maximum: 10 inch
   3. Materials
      a. Coated glass fabric
      b. 30 ounces per sq yard
      c. Sewed and cemented seams

d. Indoors
    1) Neoprene or woven nylon/polyester blend with vinyl coating
    2) Ventfabrics, Inc. Ventglas or equal
e. Outdoors
    1) Woven fiberglass with Hypalon coating
    2) Weather-resistant
    3) UV, sunlight, and ozone resistant
    4) Ventfabrics, Inc. Ventlon or equal

PART 3 EXECUTION

3.1 INSTALLATION

A. Install isolators and seismic restraints in accordance with manufacturer's written instructions

B. Vibration isolators must not cause any change of position of equipment or piping resulting in piping stresses or misalignment

C. Make no rigid connections between equipment and building structure that degrade noise and vibration isolation system herein specified
    1. Electrical conduit connections to isolated equipment shall be flexible liquid tight conduit of sufficient length to incorporate a right angle bend, an offset of not less than 8 inches or a loop to allow free motion of isolated equipment
    2. The HVAC Sub-contractor shall not install any equipment, piping or conduit which makes rigid contact with the building unless permitted in this Specification; building includes, but is not limited to, slabs, beams, columns, studs and walls
    3. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation

D. Do not use isolator leveling bolts as jacking screws

E. Verify that all installed isolators and mounting systems permit equipment motion in all directions

3.2 SEISMIC CONTROL

A. General
    1. Install seismic restraints for pipes, ducts and equipment per applicable code
    2. Design and provide restraints to prevent permanent displacement in any direction caused by lateral motion, overturning or uplift
        a. Prepare designs and include on shop drawings, including arrangements, sizes and model numbers indicated or referenced in applicable standards. Each shop drawing shall bear a Structural or Civil Engineer’s stamp and signature registered in the State of California.
        b. Where designs, etc., are neither indicated nor referenced, contractor shall submit such designs, together with supporting calculations prepared by Structural or Civil Engineer registered in State of California. Calculations shall substantiate seismic restraint capability to safely accept external forces without failure and maintain equipment in position.
        c. Capable of safely accepting external forces per CBC without failure.
    3. Provide resilient restraining devices as required to prevent equipment motion in excess of 1/4 inch
    4. Coordinate seismic bracing requirements with other sections to result in

a. Vertical pipe and duct restraints to coincide with and take place of required hangers
b. Longitudinal pipe bracing to coincide with required pipe anchors

5. Shall not short circuit vibration isolation systems or transmit objectionable vibration or noise

B. Attachments to Structure: See Section 230529 Hangers and Supports

3.3 FLOOR MOUNTED EQUIPMENT

A. Concrete housekeeping pads
1. Isolation and seismic restraint supplier to determine dimensions and thickness required
a. Minimum thickness: 5.5 inches
2. Support all vibration isolation devices and bases
3. Key with stirrups as required, integral with structural slab
4. Incorporate seismic restraint anchor plates flush with top of housekeeping pad

3.4 EQUIPMENT ISOLATION

A. General
1. Provide 1 inch operating clearance between equipment or structural bases and housekeeping pad
a. 2 inch minimum clearance for inertia bases over 96 inches in any dimension
2. Position equipment, structural base and concrete bases on blocks or wedges at proper operating height
3. Provide operating load conditions prior to transferring base isolator loads to springs and removing wedges
4. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 1/4 inch
5. Prior to start-up, clean out all foreign matter between bases and equipment
6. Verify that there are no isolation short circuits in the base, isolators or seismic restraints or conduit, pipe and duct connections
7. Position all corner or side seismic restraints with equipment in operation for proper operating clearance. Weld or bolt seismic restraints to seismic anchor plates in housekeeping pad
8. Locate spring hanger boxes directly adjacent to the structural support element above, as opposed to down at the location of the supported equipment.
9. Where isolator base pad is called for in Vibration Isolator Schedule, install pad between the isolator base and structure.
10. For isolator pads penetrated by anchors to the structure, to prevent short-circuiting, provide neoprene grommet between the anchor and isolator. Hand-tighten nut to so that grommet is not compressed then secure with lock nut.

B. Vibration Isolator Schedule

Equipment	**Base Type**	**Isolator Type**	**Isolator Static Deflection**	**Acoustical Base Pad Thickness**
In-line pumps >1 HP	None	C	1 inch	–
Floor-mounted AHUs (internally isolated)	None	F	0.1 inch	–
Suspended fan-coils	None	C	1 inch	–
Floor-mounted fans <10 HP	B-1 if fan is not self-supporting	A	1 inch	1/2 inch
Floor-mounted fans 10 HP and larger				

Equipment	Base Type	Isolator Type	Isolator Static Deflection	Acoustical Base Pad Thickness
<300 RPM	B-1 (B-2 if 50 HP or larger)	A	3.5 inch	1/2 inch
300-450 RPM	ditto	A	3 inch	1/2 inch
451-600 RPM	ditto	A	2.5 inch	1/2 inch
601-750 RPM	ditto	A	2 inch	1/2 inch
751-850 RPM	ditto	A	1.5 inch	1/2 inch
>850 RPM	ditto	A	1 inch	1/2 inch
Suspended fans direct drive				
1/3 HP and larger	None	E	0.2 inch	–
<1/3 HP	None	–	–	–

3.5 PIPING ISOLATION

A. See Section 232113 HVAC Piping

B. See Section 230529 Hangers and Supports for general support of piping including felt lined hangers for uninsulated piping.

C. Piping other than risers
   1. No vibration isolation required

D. Vertical Pipe Risers
   1. Riser Support 1
      a. Applies to copper pipe risers and welded steel less than 50 feet in length, and steel pipe risers with flexible mechanical couplings.
      b. Risers shall be laterally supported with a riser clamp at each floor set on a Type F isolation pad, 0.1 inch deflection.
   2. Riser Support 2
      a. Applies to all pipe risers other than those qualifying for Riser Support 1
      b. Riser supports shall be engineered by the vibration isolation vendor as follows.
      c. All vertical risers shall be supported by spring isolators designed to support the riser filled with water. Assigned loads must be within the building design limits at the support points.
      d. Neutral central resilient anchors close to the center of the run shall direct movement up and down. The anchors shall be capable of holding an upward force equal to the water weight when the system is drained. If one level cannot accommodate this force, anchors can be located on 2 or 3 adjacent floors. Anchors shall be Mason ADA or equal.
      e. Resilient guides shall be spaced and sized properly depending on the pipe diameter. Guides shall be Mason VSG Vertical Sliding Guides or equal.
      f. Support spring mountings shall be Type A. The initial spring deflection shall be a minimum of 0.75 inches or four times the thermal movement at the isolator location, whichever is greater.
      g. Submittals must include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing. Calculations shall include pipe stress at end conditions and branch off locations and the manufacturer must include installation instructions. Submittal must be stamped and signed by a licensed professional engineer in the employ of the vibration isolator vendor.

E. Equipment

1. Provide twin-sphere flexible couplings where shown on drawings, such as at pumps. Install per manufacturer's instructions.
2. Provide flexible hose connections where shown on drawings, such as at AC units and hydronic heat pumps. Install per manufacturer's instructions.
3. For motorized equipment not shown to have flexible connections on drawings, such as chiller, cooling towers, and boilers, provide minimum three flexible style mechanical couplings between the vibrating equipment and the first rigid support to the structure. This can be couplings that are part of elbows and other normally required fittings; it is not necessary to include couplings dedicated to this purpose.
    a. Not required at:
        1) Air handling equipment with internal fan isolation
        2) VAV boxes including fan-powered VAV boxes
        3) Equipment piped with copper piping

3.6 DUCTWORK ISOLATION

A. See Section 233100 Ducts.

B. Ductwork
1. No vibration isolation required other than flexible connections at fans

C. Flexible Connections
1. Install at all connections to fans and air handling units and as indicated on Drawings
    a. Not required at suspended direct drive fans <1/3 HP
    b. Not required at internally isolated air handling units unless shown on drawings
2. 2 inch slack in fabric; install to allow minimum movement of 1 inch in both tension and compression

3.7 WALL AND FLOOR PENETRATIONS

A. All piping and ductwork to be vibration isolated, and all piping and ductwork passing through acoustically rated partitions, shall freely pass through walls and floors without rigid contacts or connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain 0.75 inches to 1.25 inches clearance around the pipe or duct outside surfaces. For installations through air plenum partitions and through acoustically rated partitions, clearance space shall be tightly packed with fiberglass, and caulked airtight after installation of piping or ductwork. Caulk shall be Hilti CP 506 or equal.

B. For installation in rated walls, see Section 232113 HVAC Piping and Section 233100 Ducts

C. Provide sleeves and escutcheons as specified in Section 232113 HVAC Piping and Section 233100 Ducts.

3.8 SEISMIC BRACING INSTALLATION

A. Piping and Ductwork
1. Bracing system shall meet the seismic load requirements (See Section 1.3F)
2. Install all bracing and restraints per referenced Guidelines in Paragraph 1.2, where applicable
3. Where the referenced Guidelines in Paragraph 1.2 are not applicable then submit details of a proposed bracing system. The proposed system shall be stamped by a licensed civil or structural engineer and shall be submitted for approval prior to construction.

4. Coordinate seismic bracing and restraints so that required expansion provisions will not be restricted
5. Provide floor support and bracing of pipe connection risers to equipment
6. Where seismic bracing and restraints are not required refer to Section 230529 Hangers and Supports

B. Flexibly Supported Piping and Ducts
1. Provide and locate restraints to allow normal operation of systems without transmitting vibrations to building structure
2. Location of Restraints: Per referenced Guidelines in Paragraph 1.2
3. Construction of Restraints: Steel cables, installed slack

C. Rigidly Mounted Equipment
1. Secure to floor as required to prevent horizontal motion and overturning
2. Secure to walls or other equipment to prevent overturning
   a. Attach to elements capable of taking calculated loads
   b. Provide steel backing in walls as required to brace equipment and piping from wall

3.9 FIELD QUALITY CONTROL

A. Inspection by manufacturer's representative of all vibration isolating devices
1. After installation of all devices
2. Provide written report by manufacturer regarding
   a. Installation errors
   b. Improper selection of devices
   c. Other fault that could affect performance of system

B. Submit written report to Owner’s Representative
1. Include manufacturer's report indicating required corrections
2. Include report on steps to properly complete isolation work

C. See Section 230800 Mechanical Commissioning

END OF SECTION

SECTION 230553

HVAC SYSTEM IDENTIFICATION

PART 1 GENERAL

1.1 SUMMARY

A. Identify piping and equipment components of the mechanical systems to indicate their function and system served

1.2 REFERENCE STANDARDS

A. Pipe marker shall comply with ANSI/ASME A13.1

1.3 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Pipe markers	R2			
Equipment tags	R2			
Concealed equipment markers	R			

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. W.H. Brady

C. Seton

D. Marking Services, Inc. (MSI)

E. Or equal

2.2 DUCTWORK IDENTIFICATION

A. Not required

2.3 PIPING IDENTIFICATION

A. Colors

Pipe Service	Background	Lettering
Chilled water supply	Blue	White
Chilled water return	Blue	White
Heating water supply	Yellow	Black
Heating water return	Yellow	Black

B. Label Content
1. Pipe service
2. Arrow indicating flow direction

C. Labels
1. Vinyl duct markers, self-adhesive
2. Able to withstand temperatures up to 160°F
3. Minimum letter size: per ANSI/ASME A13.1
4. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

D. Provide custom marker labels for all piping for which no standard manufactured marker is available. Submit sample for approval

E. Specialty Gases piping shall be identified with Brady B-60 fiber tags, or equal, with chemical symbol on tag

2.4 VALVE IDENTIFICATION

A. Valve Tags: Not required

2.5 EQUIPMENT IDENTIFICATION

A. Nameplates
1. Tag all scheduled and uniquely tagged mechanical equipment with engraved nameplates. Nameplates shall be 1/16-inch thick, 3 x 5 or 2 x 6 laminated 2-ply plastic, center ply white, outer ply black. Form letters by exposing center ply.
2. Identify unit with building number, unit mark as shown on equipment schedules on Drawings, and service. For example: SF-1 SUPPLY FAN

2.6 TERMINAL UNITS

A. Same as Paragraph 2.5
1. Hand-written or stenciled tag on terminal casing in indelible ink also acceptable

PART 3 EXECUTION

3.1 MANUFACTURER'S IDENTIFICATION

A. Equipment manufacturer's nameplate, name or trademark shall be permanently affixed to all equipment and material furnished under this specification. The nameplates of subcontractor or distributor are not acceptable.

B. Identify model number, size, capacity, electrical characteristics, serial number, etc.

C. Leave nameplates clean, legible and with unobstructed view

3.2 PIPING IDENTIFICATION

A. All piping concealed or exposed shall have identification markers.

B. Unless the current version of the recommendations of ANSI A13.1, 1981 are more stringent, apply labels or letters after completion of pipe cleaning, insulation, painting, or other similar work, as follows:
   1. Every 20 feet along continuous exposed lines
   2. Every 10 feet along continuous concealed lines
   3. Adjacent to each valve and stubout for future
   4. Where pipe passes through a wall, into and out of concealed spaces
   5. On each riser
   6. On each leg of a “T”
   7. Locate where conspicuously visible

C. Further, apply labels or letters to lower quarters of the pipe on horizontal runs where view is not obstructed or on the upper quarters when pipe is normally viewed from above. Apply arrow labels indicating direction of flow; arrows to be the same color and sizes as identification labels.

D. Spray a protective coating of clear epoxy over markers and arrows in corrosive atmosphere areas.

3.3 EQUIPMENT IDENTIFICATION

A. All equipment and apparatus shall have identification nameplates. Cardholders in any form not acceptable.
   1. Provide identification nameplate for variable speed drives and starters provided under this Division indicating the equipment that the VFD powers.

B. Locate where conspicuously visible

C. Attach either with sheet metal screws, brass chain, or contact cement as applicable

D. Identify equipment out of view behind access doors, in unfinished rooms on the face of the access door

E. Place warning signs on machines driven by electric motors which are controlled by fully automatic starters, in accordance with Article 3281, General Industry Safety Orders

F. Nameplate Directory: Post final copy in Operation and Maintenance Manual

3.4 TERMINAL UNITS

A. Same as Paragraph 3.3

B. Identify room sensor/thermostat relating to terminal unit with indelible marker on sensor hidden by cover.

3.5 CONCEALED EQUIPMENT IDENTIFICATION

A. Where fire/smoke dampers, terminal units, and other equipment requiring routine maintenance are located above accessible ceilings, color-coded markers shall be provided as specified below to make it easier for equipment to be located by maintenance personnel.
   1. Marker
      a. DONN Fineline, narrow tee-bar (tees with flat surface less than 1/2 inch wide), or concealed spine ceilings: 1/8 inch round-head map tack
      b. Standard tee-bar ceilings: 3/8 inch round sticker made of vinyl, polyester, or PVC (paper not acceptable), equal to EMS Tough-Spots
   2. Locate marker on the ceiling tile (tack) or tee (sticker) closest to side of the equipment requiring maintenance (such as damper motor, controls, and valves).
   3. Unless otherwise directed, color codes shall be:
      a. Fire/smoke and smoke dampers: red
      b. HVAC equipment, such as terminal units, VAV boxes, and heat pumps: blue
      c. Valves such as at riser taps and riser or branch isolation valves: yellow

B. Label duct access door to fire and smoke dampers in letters not less than 1/2 inch height reading SMOKE DAMPER, FIRE DAMPER, or FIRE/SMOKE DAMPER. Indelible ink is acceptable.

END OF SECTION

SECTION 230593

TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Operational testing and adjusting of air handling equipment
   2. Balancing of air distribution systems
   3. Testing and adjustment of air terminal devices
   4. Flow testing, adjusting and balancing of hydronic systems.

1.2 REFERENCE STANDARDS

A. National Environmental Balancing Bureau Procedural Standards

B. Associated Air Balance Council National Standards

C. Testing, Adjusting and Balancing Bureau Standards

D. ASHRAE Standard 111 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilating, and Air-Conditioning Systems

1.3 QUALITY ASSURANCE

A. Contractor shall be member of Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB), or Testing, Adjusting and Balancing Bureau (TABB)

B. Contractor shall have satisfactorily balanced at least three systems of comparable type and size

C. Prior to start of testing, adjusting and balancing, verify that required Project conditions are met
   1. Systems installation is complete and in full operation
   2. All pre-functional tests have been performed
   3. Equipment has been started and tested in accordance with manufacturers' installation instructions
   4. Doors and windows are in place and closed or under normal traffic conditions

1.4 SUBMITTALS

A. All submittals shall follow Submission and Resubmission Procedures outlined in 230501 Basic Mechanical Materials and Methods.

B. Submit documentation that demonstrates
   1. Contractor is a member of AABC, NEBB, or TABB
   2. Contractor has satisfactorily balanced at least three systems of comparable type and size

C. Pre-Test Submittal
1. At least 30 days prior to starting field work, submit the following:
a. Set of final report forms
1) Complete with design conditions of all equipment and design flow rates for all equipment and devices to be tested.
2) Forms shall include blank entry space for all data requested in this Section. Carefully review requested data; standard balancing forms may not be acceptable.
3) Forms shall be in acceptable word-searchable electronic format per Section 230501 Basic Mechanical Materials and Methods.
b. Complete list of instruments proposed to be used
1) Organize in appropriate categories
2) Include data sheets for each
3) Show
a) Manufacturer and model number
b) Description and use when needed to further identify instrument
c) Size or capacity range
d) Latest calibration date
c. Provide certification that
1) All instruments have been calibrated prior to tests
2) Instruments comply with requirements of AABC, NEBB, or TABB for tests required
3) Contractor is currently certified by AABC, NEBB, or TABB
2. Do not proceed with field work until the above submittal has been approved by Owner's Representative.

D. Final Test & Balance Report
1. At least 15 days prior to Contractor's request for final inspection, submit electronic copy of final reports on approved reporting forms for review and approval by Owner's Representative. Once approved, provide required quantity of paper and electronic copies per 230501 Basic Mechanical Materials and Methods.
2. Form of Final Reports
a. Completed forms shall be typed (not hand written) and be in acceptable word-searchable electronic format per Section 230501 Basic Mechanical Materials and Methods.
b. Fully completed report forms for all systems specified to be tested and balanced including at a minimum all data specified herein to be recorded
c. Each individual final reporting form must bear
1) Signature of person who recorded data
2) Signature of air balance supervisor of reporting organization
d. When more than one certified organization performs total air balance services, firm having managerial responsibility shall make submittals.
e. Identify instruments of all types that were used and last date of calibration of each.

1.5 PROJECT REVIEW

A. Pre-Construction Review
1. Review following documents
a. Contract documents
1) Drawings
2) Specifications
3) Addenda
4) Change orders
b. Submittal data
c. Shop drawings
d. Building Automation System drawings

e. Pre-functional test reports
2. Identify potential problems from standpoint of total system balance.
3. Review design and shop drawings and specifications for
   a. Potential problems for total system balance
      1) Location of balancing devices
      2) Lack of balancing devices
      3) General System layout
      4) Architectural features
      5) Accessibility
   b. Most effective system balance procedures
   c. Scheduling and coordination requirements
4. Review submittal data for
   a. Completeness of data
   b. Conformity with contract documents
   c. Special instructions for use of balancing devices
   d. Factors for flow meters
   e. Limitations affecting accuracy of measurements
   f. Balancing forms shall show design data and submittal data where different
   g. Equipment performance data and curves
5. Review BAS drawings and specifications for:
   a. Calibration and setpoint adjustment requirements by this Section
   b. Determining most effective total system balance procedure for minimum control manipulation
   c. Coordinate required control manipulation with BAS installer
6. Submit report recommending addition and/or relocation of balancing devices, including, but not limited to
   a. Volume dampers
   b. Balancing valves (including ball and butterfly valves with memory-stops, which are used in the design for balancing)
   c. Pressure and temperature measuring points

B. Construction Review
1. Make on-site visits during progress of construction: Number of visits to be as required to perform the functions specified below.
2. Purpose of review
   a. Identify potential problem for performing total system balance
   b. Identify modifications that will affect air total system balance
   c. Schedule and coordinate total system balance with other work
   d. Identify conditions that could create hazardous environment for building occupants
3. Typical activities
   a. Check that necessary balancing and measuring hardware is
      1) In place
      2) Located properly and accessibly
      3) Installed correctly
   b. Identify and evaluate variations from system design
   c. Record data from equipment nameplates
   d. Identify and report possible restrictions in systems; such as
      1) Poorly designed duct fittings
      2) Questionable piping connections
      3) Others as may arise or based on contractor's experience
   e. Verify that construction progress will not delay total system balance
   f. Identify best location for duct traverses
   g. Identify scaffolding needs

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified herein. If not otherwise noted, the following minimum requirements apply
   1. Volt-meter: plus or minus 1 percent scale
   2. Ammeter: plus or minus 1 percent scale
   3. Ohmmeter: plus or minus 0.1 percent scale for calibrating plus or minus 0.4 degrees Fahrenheit resistance temperature sensors, plus or minus 0.25 percent scale for calibrating plus or minus 1 degrees Fahrenheit temperature sensors, plus or minus 1 percent scale for measuring motor current
   4. Ultrasonic time-of-travel strap-on flow sensor: plus or minus 5 percent of reading
   5. Other flow sensors: plus or minus 2 percent of reading
   6. Water pressure gauge: plus or minus1/2 percent scale, ASME Grade 2A
   7. Watt meter, plus or minus1/2 percent scale: 3 phase split core current transducers
   8. Temperature: plus or minus 0.4 degrees Fahrenheit

B. All equipment shall be calibrated within 6 months of use, or according to the manufacturer's recommended interval, whichever is shorter, and when dropped or damaged. Calibration tags shall be affixed or certificates readily available and proof of calibration shall be included reports.

PART 3 EXECUTION

3.1 GENERAL

A. Coordinate with work of other trades.

B. Coordinate all work with Commissioning Coordinator
   1. See Section 019100 Commissioning
   2. See Section 230800 Mechanical Commissioning

C. Report to Owner's Representative any discrepancies or items not installed in accordance with the Contract Drawings pertaining to proper balance and operation of air and water distribution systems.

D. Perform testing, adjusting and balancing in accordance with AABC, NEBB, or TABB standards.

E. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to Section 230700 Mechanical Insulation.

F. Mark equipment settings with paint or other suitable, permanent identification material, including damper control positions, valve indicators, and similar controls and devices, to show final settings.

G. Assist in performance testing where specified in Section 230800 Mechanical System Commissioning.

3.2 CONTROL SYSTEM COORDINATION

A. See Division 25 Building Automation Systems

B. System balance techniques in this Section rely on the operation of the BAS. Test and balance contractor shall coordinate schedule of work with BAS installer to ensure test and balance work can be executed and completed in a timely manner.

C. Cooperate with BAS installer in determining operating conditions and setpoints, as indicated in this Section.

D. Cooperate with BAS installer in calibrating all airflow measuring devices.

E. Obtain and receive training for required software from BAS installer for setting calibration constants in terminal devices.

3.3 WATER SYSTEMS BALANCING

A. Prepare water systems for balancing in following manner
   1. Verify the following conditions
      a. Piping systems have been flushed and treated in accordance with Section 232113 HVAC Piping
      b. Strainers have been cleaned
      c. Piping systems are completely full of water, all air properly vented
      d. All coil and heat exchanger shut-off, balance, and control valves are fully open
   2. Check pump
      a. Rotation
      b. Pump factory impeller trimming by comparing shut-off heads with pump curves from approved submittals
         1) Note that impellers on variable speed pumps should not be trimmed to design flow and head conditions. See Section 232123 Pumps.
         2) Report discrepancy in shut-off head to Owner's Representative and if impeller does not appear to be properly trimmed. Wait for direction before proceeding with pump test and balance.
   3. BAS and Central Plant Operability
      a. Do not proceed with any of the following balancing procedures until the BAS is capable of operating equipment such as fans, pumps, VAV boxes, control valves, etc. in manual and automatic modes and capable of reading sensors such as differential pressure, flow rates, temperatures, etc. of air and hydronic systems to be tested and adjusted.
      b. Do not proceed with air handler testing until chilled and hot water at design temperatures are available from the central plant.

B. Pumps
   1. Test and report for each pump at test conditions indicated in Paragraphs below.
      a. Tag
      b. Manufacturer and model of pump and motor
      c. Motor horsepower, volts, phase, full load amps
      d. Pump shut-off head from curves, measured shut-off head, and resulting impeller diameter from pump curve
      e. At test condition specified
         1) Volts and amps
         2) Calculated brake horsepower
         3) Entering and leaving gage pressure and difference in feet
         4) Flow rate deduced from pump curve
         5) For pump with variable speed drive

a) Speed (Hz)
b) Kilowatts

2. Include pump curve from approved submittals in final report.

C. Chilled Water and Hot Water Distribution System

1. Coil Test & Balance
   a. System is self-balancing. Two-way control valves at coils prevent each coil from being over-supplied with water, other than minor excursions during transients such as cool-down or warm-up. Conventional balancing (throttling of balancing valves) will increase pump energy use by not allowing aggressive differential pressure setpoint reset. Hence, do not adjust any valves on any coil or pump, except temporary adjustments where noted. All manual valves at coils and pumps shall be wide open when test and balance work is complete.
   b. Report with all control valves open to coil and all pumps (except standby pumps, where applicable) operating at full speed
      1) See Air Balance below for coil temperature data where required
      2) See Pump test data above for pump data
      3) Coils with modulating two-way
         a) Terminal tag
         b) Control valve model number and serial number
         c) Pressure drop across coil
         d) Flow as measured by calibrated balancing valve (where applicable). Determine flow by either of the following:
            1. Use test plugs to measure pressure drop across the coil and estimate flow using coil manufacturer's submittal data of flow vs. pressure drop. This option shall only be used when design coil pressure exceeds 5 feet.
            2. Use test plugs to measure pressure drop across the control valve and calculate flow using valve manufacturer's submitted Cv.
2. HW Pump Variable Speed Drive Setpoint Determination
   a. For systems with variable speed drives, determine maximum differential pressure setpoint (DPmax) in conjunction with the BAS installer as follows.
      1) Fully open all control valves serving coils that are located downstream of the differential pressure sensor.
      2) Fully close all control valves serving coils that are located upstream of the differential pressure sensor.
      3) Start pump(s). Manually adjust speed slowly until design flow (or design pressure drop, for coils without calibrated balance valves) is just achieved through all open coils without modulating any balance valves. One coil should be just at design flow, while others should be at or above design flow.
      4) Once flow condition in previous step is achieved, note the BAS system differential pressure reading at the differential pressure sensor. This reading becomes the differential pressure setpoint. Using pressure taps at differential pressure sensor and handheld digital pressure sensor, verify accuracy of BAS reading.
      5) If there are multiple differential pressure sensors, repeat steps above for each sensor.
   b. Convey to the BAS installer
      1) Differential pressure setpoint
      2) Any discrepancy between BAS differential pressure reading and handheld measurement
   c. Report at condition described above
      1) Differential pressure setpoint and concurrent reading of handheld measurement: Initials of BAS installer to indicate that the information was transmitted to them.
      2) Tag of coils downstream of differential pressure sensor, along with the following for each
         a) Design flow rate and pressure drop
         b) Tested flow rate and pressure drop with differential pressure at setpoint determined above
      3) Water flow rate through flow meter (where applicable), through BAS

4) See Pump test data above for pump data

3. Control Valve Shut-off Test
   a. Close all control valves in the system through the BAS. Run all pumps at full speed.
      1) Verify that all control valves remain shut with no measurable flow, as indicated by pump differential pressure and any temperature rise across coils.
      2) Do not run pumps deadheaded for more than 5-minutes at any one time.
      3) After test, release control valves to automatic operation through the BAS.
   b. Report at condition described above
      1) Tag of coils where flow is detected: Initials of BAS installer to indicate that this information was transmitted to them.
      2) Measured pump inlet and outlet pressures, and difference converted to feet
      3) Differential pressure reading at all differential pressure sensors, through BAS

3.4 AIR SYSTEM BALANCING

A. General
   1. Do not operate fan systems for test or balance until spaces served have been cleaned of dust and debris, to avoid contamination of supply air or return air paths and equipment.
   2. Filters
      a. Check that filters of the type specified are installed, oriented in the proper airflow direction, free of bypass, and clean.
      b. Make no adjustment for dirty filters; fans were selected for clean filters at design airflow.
      c. For systems with construction prefilters and high efficiency final filters
         1) Perform all zone level balancing with only pre-filter installed, no final filter, and system operating on 100 percent outdoor air.
         2) Immediately prior to pre-occupancy 100 percent outdoor air purge (see procedure specified under Section 230501 Basic Mechanical Materials and Methods), remove and discard prefilters and install clean final filters. With final filters in place, perform tests of air handling unit as described for appropriate AHU type below. After system testing and balancing is complete, conduct 100 percent outdoor air purge per Section 230501 Basic Mechanical Materials and Methods.
   3. In cooperation with BAS installer, set adjustments of automatically operated dampers and valves to operate as indicated.
   4. Balance hydronic systems prior to air balance and have operational during air balance for air temperature measurements where specified.

B. Air Outlets
   1. Adjust diffusers' throw pattern prior to balance as indicated below unless otherwise indicated on Drawings. Review manufacturer's instructions for proper diffuser blade or weir gate positions to provide this throw pattern as it is not always intuitive. It is TAB contractor's responsibility to adjust throw patterns for all adjustable throw diffusers. If diffuser has a fixed throw pattern and is incorrectly installed, HVAC contractor shall correct pattern prior to balance.
      a. Ceiling diffusers: As indicated on the Drawings.
         1) Star pattern diffuser deflectors shall be adjusted for corner blow pattern unless otherwise indicated on Drawings.
      b. Slot diffusers supplying cooling-only, or heating and cooling with ceilings 15 feet and lower: Adjust to throw away from adjacent walls along the ceiling toward the center of the room served.
      c. Slot diffusers supplying heating-only, or heating and cooling with ceiling above 15 feet: Adjust to throw downward and slightly toward adjacent wall.
      d. Double-deflection grilles: Adjust rear blades horizontal 22 degree upward and splay front blades in 45 degree pattern at each end gradually rotating to be almost straight at blades in center of grille.

e. Thermafusers: Install directional baffles (or verify factory installation) to achieve the blow pattern shown on plans and schedules.

2. Test and adjust each diffuser, grille and register to within plus or minus 10 percent of design requirements
   a. Start with all dampers wide open.
   b. Adjust dampers, starting with nearest to terminal unit or fan. Make adjustments using duct mounted volume dampers rather than dampers at diffuser face (if any) unless absolutely required.
   c. At least one damper shall remain wide open at end of balance.
3. Thermafusers
   a. See manufacturer's instructions.
   b. All measurements shall be made with all appearance panels in place.
   c. Design flow
      1) Fully open the damper using the balancing lever
      2) Balance Thermafusers to design flow just like any other diffuser per Paragraph 3.4B.2 adjusting the VAV box damper through the BAS as needed so at least one balancing damper is wide open.
      3) Once all Thermafusers are at design flow and at least one balancing damper wide open, the VAV box discharge static pressure reading becomes the design setpoint, (DPmax). Coordinate with the BAS system and installer to record this value. No field measurement of static pressure is required, only the BAS sensor reading.
   d. Minimum flow
      1) Set minimum flow adjustment dial to 10% (the factory setting)
4. Plenum return air grilles or slots in lights: No balance required
5. Report
   a. Tag each grille, diffuser and register and mark tag on copy of floor plan.
   b. For each grille, diffuser and register, indicate tag, size, type, and effective area (where applicable).
   c. Required velocity/cubic feet per minute
   d. Initially tested velocity/cubic feet per minute
   e. Finally tested cubic feet per minute after adjustments
   f. Thermafuser VAV box static pressure setpoint; also convey to BAS contractor.

C. Terminal Boxes
1. Balancing contractor shall provide laptop computer or other device for communicating with BAS system, using software provided by BAS installer. Cooperate with BAS installer to learn how to use software to calibrate BAS zone controller.
2. Terminal box calibration procedure listed below may be modified based on specific features or limitations of digital controller and recommendations of the controller manufacturer. Submit revised procedure for approval by Owner's Representative along with pre-test submittal per Paragraph 1.4C.
3. Use BAS terminal "commissioning" software where available and record all calibration and test data through the BAS.
4. Zero transmitter prior to each test.
5. Adjust BAS calibration constants so that the VAV box controller and measured air flow rate at air outlets matches BAS reading within range listed at all of the following conditions at a minimum:
   a. Maximum airflow setpoint, ±5%
   b. Controllable minimum airflow setpoint, ±10%. The controllable minimum value shall be that determined by the BAS contractor per Section 250000.
   c. Zero flow
6. Terminal fans (fan-powered boxes)
   a. Adjust speed to achieve design cfm within 10 percent
   b. For series-flow boxes, adjust BAS setpoint to allow VAV damper to operate at maximum airflow rate: Increase fan speed until there is no backflow through plenum opening.

c. For ECMs with speed controlled by BAS, set maximum speed via BAS interface and note speed setpoint in air balance report.

7. Report
   a. Tag, manufacturer, and model
   b. VAV maximum cooling flow rate, design and measured
   c. VAV minimum flow rate, design and measured
   d. BAS calibration coefficients at all calibration points

D. BAS airflow measuring stations (AFMS)
1. For cooling AHU AFMS
   a. Test Conditions
      1) Command all VAV boxes to full open.
      2) Override the economizer to 100% outdoor air, i.e. configure the outdoor air damper to be 100% open and the return air damper to be 0% open.
      3) Start supply fan and run it slowly from 10% speed up to 100% speed, in 10% increments with a pause at each step to allow time for the VAV boxes to communicate. At each 10% increment, measure and report:
         a) Sum of VAV box airflows (should be displayed on BAS AHU graphic)
         b) Airflow measurement station airflow reading
         c) Traverse across supply air duct, filter bank, or other location where the most accurate airflow reading is possible
   b. Plot the speed vs. all three measured airflows. They should be linear and the three readings should be within 10% of each other.
2. For factory calibrated AFMS: If measured airflow and BAS readings differ by more than 10%, consult with Owner's Representative for recalibration instructions. Do not change factory calibration without written direction.
3. For field calibrated AFMS: Coordinate with BAS installer to adjust calibration coefficients. Report coefficients in air balance report.

E. Air Handling Unit and Fan-coil Airflow Rate Readings
1. Total supply air quantities shall be determined at all of the following where applicable
   a. Pitot traverse in the supply duct downstream, positive pressure side of the fan
   b. Pitot traverse at coil or filter bank
   c. Totaling the readings of individual air outlets
   d. Totaling the readings of individual terminals as read through the BAS
   e. Supply fan airflow sensor reading as read through the BAS
2. Total return air quantities shall be determined at all of the following where applicable
   a. Pitot traverse in the return air duct or damper entering air handler
   b. Totaling the readings of individual air outlets, if ducted return system
   c. Totaling reading of each return air shaft inlet, if multi-story plenum return system
   d. Return fan airflow sensor reading as read through the BAS
3. Outside air quantities shall be determined by all of the following where applicable
   a. Subtracting pitot traverses of supply and return ducts
   b. Pitot traverse of outdoor air intake duct
   c. Outdoor airflow sensor reading as read through the BAS
   d. Note: Balance by measurement of return air, outside air, and mixed air temperatures shall not be used due to inherent inaccuracy.

F. Variable Air Volume Air Handlers
1. Adjust fan speed using manual adjustment of variable speed drive for testing only. Do not change or adjust sheaves.
2. Supply fan DP Setpoint.
   a. Establish maximum static pressure setpoint (DPmax) in conjunction with the BAS installer as follows. All adjustments made via the BAS, not field measurements except as noted.

b. Test Conditions
    1) Set all boxes to operate at maximum airflow setpoints; allow controls to stabilize.
    2) For cooling systems only to account for diversity: Shut off boxes, starting with boxes whose dampers are the most closed, as indicated by the BAS, and upstream of the DP sensor, until the airflow equals scheduled design airflow rate.
c. Procedure
    1) Manually lower fan speed slowly while observing VAV box airflow rates downstream of the static pressure sensor. Stop lowering speed when one or more VAV box airflow rates drops 10 percent below maximum airflow rate setpoint.
    2) Once flow condition in previous step is achieved, note the BAS system static pressure reading at the duct static pressure sensor.
        a) This reading becomes the maximum static pressure setpoint.
        b) Using pressure taps at differential pressure sensor and handheld digital pressure sensor, verify accuracy of BAS reading.
d. If there are multiple static pressure sensors, repeat steps above for each sensor. Each sensor will have its own setpoint.
e. Convey to the BAS installer
    1) Static pressure setpoints
    2) Any discrepancy between BAS differential pressure reading and handheld measurement
f. Report
    1) Static pressure setpoint and concurrent reading of handheld measurement: Initials of BAS installer to indicate that the information was transmitted to them.
    2) Tag of VAV boxes that dropped below design maximum airflow rate in tests above. These are the critical boxes, those requiring the largest static pressure.
    3) Concurrent fan data
        a) Volts and amps
        b) Amps and kilowatts from variable speed drive
        c) Variable speed drive speed in hertz
        d) Entering and leaving fan static pressure
        e) Flow rate, summed from BAS terminals
        f) Fan airflow sensor reading from BAS, where applicable

3. Minimum outside air flow
    a. Supply air fan and return air fan (if any) shall first be operating at design airflow. For VAV systems with diversity, close enough boxes close to fan to reduce supply airflow to scheduled design condition.
    b. For systems with outdoor airflow measuring stations, see Paragraph 3.4D. Adjust dampers to achieve minimum design outdoor air flow rate via the BAS.
4. Test with system operating at design fan and minimum outside air flow conditions described above and report the following on a schematic of the system:
    a. Tags of all equipment
    b. Manufacturer and model of all fans and motors
    c. Motor horsepower, rpm, volts, phase, full load amps
    d. Sheave data at motor and fan; belt data
    e. Fan airflow rate at all locations measured, as listed above
    f. Final measured fan speed and amps
    g. Amps and kilowatts from variable speed drives
    h. Variable speed drive speed in hertz
    i. Static pressures measured at
        1) Return air plenum
        2) Mixed air plenum
        3) Downstream of relief fan (where applicable)
        4) Downstream of filter
        5) Downstream of coil
        6) Discharge of supply fans

7) At static pressure sensor
j. Concurrent airflow rate readings from BAS airflow sensors, including sum of VAV box airflow rates
k. Minimum BAS outdoor air control setpoints and signals as applicable
l. Coil Performance
1) Test with
a) Associated pumps running in automatic maintaining differential pressure setpoint determined above
b) Central plant cooling (heating) equipment operational
c) Controls adjusted to provide coil design water temperature entering coil
d) Fan is running at design airflow
e) Fully open control valve, allow steady-state to be reached, and measure
2) Measure and report on a schematic of the system
a) Entering water temperature
b) Leaving water temperature
c) Coil differential pressure drop
d) Coil flow rate, deduced from manufacturer's coil flow vs. pressure drop data, see submittals
e) Coil entering drybulb and wetbulb to cooling coils, drybulb only for heating coils
f) Leaving supply air drybulb and wetbulb from cooling coils, drybulb only for heating coils

5. Relief Fans
a. Test Conditions
1) Economizer in 100% outdoor air position
2) Supply fan at design supply air rate
3) All doors and windows closed in area served by air handler
4) All exhaust fans on in area served by air handler
b. Procedure
1) Measure building pressure using BAS sensor.
2) Manually adjust fan speed at variable speed drive to achieve than 0.05" building pressure.
a) Fan speed may exceed 60 Hz if necessary. Do not change or adjust sheaves.
b) If required fan speed exceeds 60 Hz, convey maximum speed to BAS contractor.
3) At the above design conditions, measure fan inlet and outlet pressures and measure total relief air quantities with pitot tube traverse of main ducts near the fan inlet or outlet where possible.
c. Report
1) Amps and kilowatts from variable speed drive
2) Variable speed drive required speed in hertz
3) Inlet and outlet static pressure
4) Building static pressure

G. Drain Pan Testing
1. This test shall be performed for all drain pans including
a. Primary condensate drain pans on all air handling units and fan-coils
b. Humidifier and evaporative cooler sump pans that include a drain-down cycle
2. This test does not apply to:
a. Auxiliary drain pans under fan-coils
b. Other drain pans for emergency use not expected to be wet during normal operation
3. Procedure
a. Pan Slope Test
1) Turn AHU off.
2) Plug the drain at the discharge air gap.
3) Fill the drain pan with water until standing water covers all of the pan.

4) Remove the test plug and verify all of the water drains, leaving puddles no larger than 2" in diameter and 1/8" deep anywhere in the pan.

b. Trap Sizing Test – Blow-Through Fans
   1) Plug the drain at the discharge air gap.
   2) Open the air handler/fan-coil coil access panel and fill the drain pan until all areas of the pan are covered with at least ½" of water. Close the access panel.
   3) Configure and operate the air handler/fan-coil at design operating conditions as defined above herein. The intent is that the coil section will be at the highest expected operating pressure.
   4) Remove drain and observe condensate flow at drain pipe discharge air gap. Within a few minutes, there should be little to no flow.
   5) Use theatrical smoke or other flow indicator near the drain vent/cleanout and verify that air is not being blown out of the trap. If airflow is detected, the trap is dry and the trap depth, as measured from the centerline of the drain connection to the centerline of the bottom of the trap, is too shallow.

c. Trap Sizing Test – Draw-Through Fans
   1) Plug the drain at the discharge air gap.
   2) Open the air handler/fan-coil coil access panel and fill the drain pan until all areas of the pan are covered with at least ½" of water. Close the access panel.
   3) Configure and operate the air handler/fan-coil at design operating conditions as defined above herein. The intent is that the coil section will be at the lowest expected operating pressure.
   4) Remove drain and observe condensate flow at drain pipe discharge air gap. Within a few minutes, there should be little to no flow.
   5) Use theatrical smoke or other flow indicator near the drain vent/cleanout and verify that air is not being drawn into the trap. If airflow is detected, the trap is dry and the trap depth, as measured from the centerline of the drain connection to the centerline of the bottom of the trap, is too shallow.
   6) Place a bucket or other receptacle at the drain discharge to capture condensate runoff.
   7) Turn off air handler/fan-coil fan. Additional runoff will occur from the P-trap, and possibly from the AHU if the drain pan is still partially full. The vertical distance from the centerline of the unit connection to the drain connection is "A". If the amount of water in the receptacle after runoff stops exceeds the condensate pipe volume determined based on the nominal pipe diameter and "A", then moisture was still standing in the pan at the end of the test, indicating future water retention problems are likely. If so, the distance "A" needs to be extended. Otherwise, the pan was dry, and the install is acceptable.

H. Constant Volume & Variable Volume Exhaust Fans and Recirculating Fan-Coils
   1. See Paragraph 3.4B for air outlet balancing
   2. Total air quantities for fan shall be determined by both
      a. Pitot tube traverse of main ducts near the fan inlet, and
      b. Totaling the readings of individual air outlets
   3. Total air quantities shall be obtained within 10 percent of design by adjustment of fan speed
      a. Constant speed fans
         1) Adjust sheaves on fans with adjustable sheaves.
         2) Change sheaves on fans with fixed sheaves.
         3) Adjust speed potentiometer for ECMs
      b. Variable speed fans
         1) Adjust maximum fan speed at ECM or VFD
   4. Report
      a. Tag
      b. Manufacturer and model of fan and motor
      c. Sheave data at motor and fan; belt data

d. Motor horsepower, rpm, volts, phase, full load amps
e. Fan airflow rate at all locations measured, as listed above
f. Final measured amps
g. Inlet and outlet static pressure

I. Life Safety Systems
1. Review Smoke Control Report provided by Owner's representative for required airflow and pressure differential requirements, where applicable.
2. All work shall be done under direction of Owner's life safety commissioning agent and in coordination with fire alarm/smoke control system installer.
3. Atrium Exhaust
a. Configure smoke dampers and make-up operable openings for atrium smoke control mode. Verify dampers/makeup openings are in the required position indicated in Smoke Control Report via the feedback lights provided at the fire alarm/smoke control panel.
b. Release (close) all smoke doors to atrium.
c. Measure atrium exhaust rate at air openings from atrium to the relief fan mechanical plenum.
d. Adjust exhaust fan speed until desired atrium exhaust rate and differential pressure is achieved relative to adjacent smoke zones.
4. For variable speed driven fans, adjust preset speed setpoint in variable speed drive so that desired speed is achieved when life safety system contact closes. Only after final tests are complete, configure variable speed drive so that contact closure results in "run to destruct" operation (no safeties) as required by code.
5. Report
a. Tag
b. Manufacturer and model of fan and motor
c. Sheave data at motor and fan; belt data
d. Motor HP, rpm, volts, phase, FLA
e. Fan airflow rate at all locations measured, as listed above
f. Final measured fan speed and amps
g. Inlet and outlet static pressure
h. Variable speed drive fan preset speed signal

3.5 ADDITIONAL COSTS

A. Fans: If drives are not capable of being adjusted to meet required performance, inform Owner's Representative and indicate added price to supply and install required sheaves. Do not include sheave changes in initial bid.

B. Pumps: If impeller must be trimmed, inform Owner's Representative and indicate added price to trim impeller and replace. Do not include impeller trim in initial bid.

C. Do not proceed until work is approved by Owner's Representative.

3.6 SPOT CHECKING

A. Spot checks shall take place after test and balance work is complete and reports have been prepared and approved.

B. Spot checks shall be witnessed by an Owner's Representative. Schedule spot checks with Owner's Representative at least 1 week prior to proposed test date.

C. Owner's Representative shall select subsets of any tested and balanced air or hydronic system to be spot-checked on the day of tests without prior notice to the Contractor.
   1. Spot-checking will not require more than one working day.
   2. If additional spot checks are requested by the Owner's Representative causing the time limit above to be exceeded, inform Owner's Representative and indicate added price to perform the additional tests. Do not include additional tests in initial bid.

D. Discrepancies
   1. If any of the spot-check measurements differ more than 15 percent from those documented in test and balance reports, the Contractor shall completely rebalance the associated system. For balance discrepancies at or downstream of a VAV box, rebalance only is required at or downstream of that box.
   2. If discrepancies as described above are found on more than 25 percent of the spot-checks for air systems, all air systems shall be rebalanced.
   3. If discrepancies as described above are found on more than 25 percent of the spot-checks for hydronic systems, all hydronic systems shall be rebalanced.
   4. Rebalance work shall be witnessed by an Owner's Representative at the option of the Owner's Representative.
   5. All rebalance work shall be documented and documentation shall be resubmitted as specified above.
   6. All rebalance work shall be provided at no additional cost to the Owner.

3.7 TRAINING OWNER PERSONNEL

A. See Section 230800 Mechanical Commissioning.

B. Go over the final Testing, Adjusting and Balancing Report, explaining the layout and the meanings of each data type.

C. Discuss any outstanding deficient items in control, ducting, piping or design that may affect the delivery of air or water.

D. Identify and discuss any systems or system components that are not meeting their design capacities.

E. Discuss any temporary settings and steps to finalize them for any areas that are not finished or fully occupied.

F. Any other appropriate points that may be helpful for facilities operations, relative to testing, adjusting and balancing or the mechanical systems.

END OF SECTION

SECTION 230700

HVAC INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Work Included in This Section: Materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Piping insulation
   2. Pipe insulation jacket
   3. Equipment insulation
   4. Ducts and plenums, thermal insulation
   5. Duct and plenums, acoustic insulation

1.2 REFERENCE STANDARDS

A. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate

B. ASTM C177 – Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

C. ASTM C335 – Steady-State Heat Transfer Properties of Horizontal Pipe Insulation

D. ASTM C585 – Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe

E. ASTM C921 – Properties of Jacketing Materials for Thermal Insulation

F. ASTM E84 – Surface Burning Characteristics of Building Materials

G. ASTM E96 – Water Vapor Transmission of Materials

H. ASTM E1222 − Standard Test Method for Laboratory Measurement of the Insertion Loss of Pipe Lagging Systems

I. ASTM D 5590 - Standard Test Method for Determining the Resistance of Coatings to Fungal Defacement

J. ASTM F 1249 -- Standard Test Method for Water Vapor Transmission Rate Through Plastic Film Using a Modulated Infrared Sensor

K. NFPA 255 – Surface Burning Characteristics of Building Materials

L. SMACNA – HVAC Duct Construction Standards - Metal and Flexible

M. UL 723 – Surface Burning Characteristics of Building Materials

1.3 DEFINITIONSDuct Dimensions
   1. Where acoustical liner is indicated on the Drawings the duct sizes indicated shall be clear inside dimensions unless duct size is specifically indicated as outside dimensions (OD)

1.4 QUALITY ASSURANCE

A. Source Quality Control
   1. Service: Use insulation specifically manufactured for service specified
   2. Labeling: Insulation labeled or stamped with brand name and number

B. Applicator: Company specializing in performing the work of this section with minimum three years experience

1.5 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Equipment insulation	R			
Piping insulation	R			
Jackets	R			
Duct insulation, wrap and liner	R			
Adhesives and coatings	R2			
Mechanical fasteners	R2			

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Insulation: Fiberglass
   1. Owens-Corning Fiberglass Corporation
   2. Manville
   3. Certainteed Corporation
   4. Knauf
   5. Or equal

C. Insulation: Elastomeric Closed Cell
   1. Armacell, Inc.
   2. Rubatex Corporation
   3. Or equal

D. Weatherproof Aluminum Jacket
   1. Childers Products Company
   2. Insul-Coustic/Birma Corporation
   3. Or equal

E. Pre-molded pipe fitting covers and Jacketing
   1. Manville: Zeston
   2. Childers Products Company
   3. Proto Corporation
   4. Insul-Coustic/Birma Corporation
   5. Or equal

F. Adhesives, Coatings, and Sealants
   1. Foster
   2. Childers
   3. Epolux Mfg. Corporation
   4. Insul-Coustic/Birma Corporation
   5. Armacell
   6. Or equal

G. Mechanical Fasteners
   1. AGM Industries, Inc.
   2. Miracle Adhesives Corporation
   3. Grip-Nail
   4. Or equal

2.2 GENERAL

A. Energy Codes: The current versions of California Title 24 and California Building Code shall govern where requirements for thickness exceeds thickness specified

B. All insulation materials, including jackets, facings, adhesives, coatings, and accessories are to be fire hazard rated and listed by Underwriters' Laboratories, Inc., using Standard UL 723 (ASTM E-84), (NFPA-255), (ASA A2.5-1963)
   1. Flamespread: maximum 25
   2. Fuel contributed and smoke developed: maximum 50
   3. Flameproofing treatments subject to deterioration from moisture or humidity are not acceptable

C. Insulation and accessories shall not provide any nutritional or bodily use to fungi, bacteria, insects, rats, mice, or other vermin, shall not react corrosively with equipment, piping or ductwork, and shall be asbestos free: Duct lining shall meet ASTM C1136 and ASTM C665 for biological growth in insulation

D. Products shall not contain or be coated with any PBDEs.

2.3 INSULATION MATERIALS

A. Pipe Insulation
   1. Fiberglass
      a. Molded: one piece, maximum 0.26 K factor at 75 degrees Fahrenheit mean temperature: Owens-Corning ASJ/SSL-II Pipe Insulation or equal
      b. Blanket: minimum 1 lb. density, maximum 0.28 K factor at 75 degrees Fahrenheit mean temperature: Owens-Corning Faced Duct Wrap or equal
      c. Board: Density as noted, maximum 0.26 K factor at 75 degrees Fahrenheit mean temperature: Owens-Corning 700 Series with face or equal
   2. Flexible, closed cell elastomeric thermal insulation
      a. Insulation ASTM C534
      b. Service rating of 220 degrees Fahrenheit

c. Density 3 to 6 pounds per cubic foot
d. Closed cell foam: Vapor permeability ASTM E96 0.2 perm
e. Max moisture absorption: 1.0 percent by volume, 10 percent by weight
f. Molded pipe insulation
1) Maximum 0.27 K factor at 75 degrees Fahrenheit mean temperature
2) Maximum water vapor transmission rating of 0.17 perm-inches
g. Sheet insulation
1) Maximum 0.28 K factor at 75 degrees Fahrenheit mean temperature
2) Maximum water vapor transmission rating of 0.17 perm-inches
h. Seal with Rubatex adhesive or equal
i. Armacell Armaflex or equal

3. Calcium Silicate
a. Insulation ASTM C 533, Type I
1) ESLIN Industrial Insulation also acceptable
b. Sectional with 14 pounds per cubic foot nominal density
c. 0.45 maximum K-factor at 300 degrees Fahrenheit mean temperature and 1200 degrees Fahrenheit maximum service rating
d. Waterproofed
e. Flexural Strength 100 pounds per square inch
f. JM Thermo-12 Gold or equal

4. Underground pipe insulation: See Section 232113 HVAC Piping

B. Jackets
1. Factory Applied Vapor Barrier All Service Jacket (ASJ)
a. ASTM C921, White kraft paper bonded to aluminum foil
b. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches
c. Secure with self sealing longitudinal laps and butt strips.
d. Seal all seams with vapor barrier coating.
e. Coat all insulated fittings, elbows, and valves with vapor barrier coating and reinforcing mesh.
f. Tie Wire: See Paragraph E.1, with twisted ends on maximum 12 inch centers
g. Vapor Barrier Lap Adhesive: Compatible with insulation

2. Aluminum Jacket: ASTM B209
a. Use for weatherproof jacket
b. Thickness: 0.016 inch sheet
c. Finish: Embossed
d. Joining: Longitudinal slip joints and 2 inch laps
e. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner
f. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel

3. Preformed PVC
a. Polyvinylchloride covers similar to Manville Zeston.
b. Color: white

4. Equipment insulation facings: Foil-scrim-kraft laminate of aluminum foil facing, glass scrim reinforcing, kraft paper backing

C. Preformed Pipe Fitting Covers
1. Aluminum
a. Factory fabricated formed covers
b. General Aluminum Supply Corporation GASCO or equal

2. PVC
a. Factory fabricated formed covers
b. Manville Zeston or equal
c. Grooved end piping: Proto Corporation Losmoke or equal

D. Adhesives and coatings
   1. Foster and Childers product names and figure numbers or approved equal
      a. Lagging adhesive: Foster 30-36; Childers CP-50AMV1
      b. Vapor barrier coating:
         1) Foster Vapor Safe 30-80
         2) UP Label, comply with MIL-C-19565C, Type II; fire and water resistant
         3) Permeance no greater than 0.08 perms at 37 mil dry film thickness as test by ASTM F 1249
      c. Vapor-seal adhesive (lap adhesive): Foster 85-60
      d. Fiberglass adhesive (duct liner and duct wrap adhesive): Meets ASTM C916 Type II. Foster 85-60; Childers CP-127
      e. Cellular glass bedding and sealing compound adhesive: Foster Foamseal 30-45; Childers CP-70
      f. Outdoor vapor barrier coating: Foster 30-90. Permeance no greater than 0.08 perms at 37 mil dry film thickness as test by ASTM F 1249.
      g. Elastomeric insulation: 520 contact adhesive

E. Wire, banding and fastening devices
   1. Wire: minimum 16 gauge copper clad annealed steel wire
   2. Bands: 3/4 inches nominal width with wing seals, of minimum thickness as follows:
      a. Aluminum: 0.007 inches. Except where exposed to weather, 0.020 inches
      b. Galvanized steel: 0.005 inches
      c. Stainless steel: 0.010 inches
   3. Staples: outward clinching type of corrosion resistant steel

F. Mechanical Fasteners
   1. Mild steel, copper plated
   2. AGM Industries Power Base insulation pins or equal
   3. Insulation washers
      a. Galvanized steel
      b. 1- 1/2 inch diameter
      c. AGM Industries SLW-1 or equal

G. Provide a continuous vapor seal for any service piping that carries liquid below 60 degrees Fahrenheit. Coat all ASJ vapor retarder seams with vapor barrier coating to prevent moisture ingress. Coat all ASJ seams with vapor barrier coating.

H. Pre-insulated pipe support and shields
   1. Provide insulated pipe supports for all insulated pipe and tubing.
   2. Hangers and supports shall fit outside of all pipe insulation and insulation inserts. See Section 230529 Hangers and Supports
   3. Insulated pipe supports
      a. Pipe Shields, Inc. or equal
      b. Waterproof calcium silicate or polyurethane insulation insert
      c. Galvanized steel or aluminum shield
      d. Minimum temperature rating equal to maximum design fluid temperature plus 25ºF
      e. Load rated, based upon testing and analysis in conformance with the latest edition of the following codes: ASME B31.9, MSS SP-58, MSS SP-69 and MSS SP-89
   4. Pipe supports for use on flat surfaces shall have integral load distribution plates coated with zinc primer minimum 3 mils thick.
   5. Install pre-insulated pipe supports per manufacturer's installation instructions. Shield lengths and gauges shall also be per manufacturer's recommendations.
   6. Tape all butt joints where pipe insulation butts up against hanger shield
      a. On hot pipe, apply three inch wide vapor barrier tape or band over the butt joint

b. On cold pipe, apply a wet coat vapor barrier lap cement on all butt joints and seal the joints with a minimum of three inch wide vapor tape or band and vapor barrier coating.

I. Fire-stopping
1. At pipe penetrations through rated assemblies
2. Commercial pipe sleeve assemblies that are UL listed and that have been approved by the fire marshal for this purpose
3. Insulation shall be continuous through penetration.

J. Accessories
1. Insulation Protection Saddles: 12-inch long, 16 gauge steel
2. Paint: Ultraviolet resistant latex paint with special adherence capabilities to the fitting covers, elastomeric, aluminum facing, Kraft paper, tapes and adhesives

K. Equipment Insulation
1. Glass fiber, semi-rigid
   a. Insulation: ASTM C612; rigid, noncombustible
      1) 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees Fahrenheit
      2) Maximum service temperature: 450 degrees Fahrenheit
      3) Maximum moisture absorption: 0.1 percent by volume
      4) Density: 3.0 pounds per cubic foot density
   b. Vapor Barrier Jacket
      1) Kraft paper bonded to aluminized film
      2) Moisture vapor transmission: ASTM E96; 0.04 perm
      3) Secure with self sealing longitudinal laps and butt strips. Minimum lap 2 inches
      4) Secure with bands, adhesive or ties
   c. Facing: 1 inch galvanized or stainless steel hexagonal wire mesh stitched on one face of insulation
   d. Vapor Barrier Lap Adhesive: Compatible with insulation
   e. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool
2. Jackets
   a. Aluminum
   b. Use for weatherproof jacket
   c. Thickness: 0.016 inch sheet
   d. Finish: Embossed
   e. Joining: Longitudinal slip joints and 2 inch laps
   f. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner
   g. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel
3. Equipment insulation facings: Foil-scrim-kraft laminate of aluminum foil facing, glass scrim reinforcing, kraft paper backing
4. Wires, bands and fastening devices
   a. Wires: Minimum 16 gage galvanized steel wire
   b. Bands: 3/4 inch nominal width wing seals, of minimum thickness as follows
      1) Aluminum: 0.007 inches indoors. Where exposed to weather 0.020 inches
      2) Stainless Steel: 0.010 inches

L. Duct Insulation
1. Duct Wrap with Vapor Barrier; Type DW-V
   a. Insulation
      1) ASTM C553
      2) Flexible, noncombustible blanket
      3) K-value: ASTM C518, 0.3 at 75 degrees Fahrenheit
      4) Maximum service temperature: 250 degrees Fahrenheit

5) Maximum moisture absorption: 0.20 percent by volume
6) Minimum density: 0.75 pounds per cubic foot

b. Vapor Barrier Jacket
1) Factory installed Foil Scrim Kraft (FSK)
2) Kraft paper reinforced bonded to aluminized film
3) Moisture vapor transmission: ASTM E96 Procedure E; 0.02 perm

c. Vapor Barrier Tape: Kraft paper reinforced bonded to aluminized film, with pressure sensitive rubber based adhesive

d. Owens-Corning All Service Faced Duct-Wrap or equal

2. Duct Board without Vapor Barrier; Type DB
a. Insulation
1) ASTM C612
2) Rigid, noncombustible blanket
3) K-value: ASTM C518, 0.25 at 75 degrees Fahrenheit
4) Maximum service temperature: 250 degrees Fahrenheit
5) Maximum moisture absorption: 0.20 percent by volume

b. Owens-Corning Type 703 or equal

3. Duct Board with Vapor Barrier; Type DB-V
a. Insulation
1) ASTM C612
2) Rigid, noncombustible blanket
3) K-value: ASTM C518, 0.25 at 75 degrees Fahrenheit
4) Maximum service temperature: 250 degrees Fahrenheit
5) Maximum moisture absorption: 0.20 percent by volume

b. Vapor Barrier Jacket
1) Factory installed Foil Scrim Kraft (FSK)
2) Moisture vapor transmission: ASTM E96 Procedure E; 0.02 perm

c. Vapor Barrier Tape: Kraft paper reinforced bonded to aluminized film, with pressure sensitive rubber based adhesive

4. Tie Wire: Annealed steel, 16 gage

M. Duct and Plenum Lining
1. Rectangular Duct Lining; Type AL
a. Material
1) Insulation: ASTM C423
2) K-value: ASTM C518, 0.23 at 75 degrees Fahrenheit
3) Maximum service temperature: 250 degrees Fahrenheit
4) Maximum moisture absorption: 0.20 percent by volume
5) 1-1/2 pounds per cubic foot unless shown otherwise to be 3 pounds per cubic foot
6) Minimum noise reduction coefficient (NRC) rating of 0.7 at 1 inch, 0.9 at 2 inch

b. Interior air-side surface
1) Smooth black neoprene or matte facing overlay on air side. Coating shall conform to NFPA 90A, ASTM C665, ASTM G21
2) Suitable for velocity up to 4000 feet per minute
3) Meet erosion test method described in UL publication No. 181
4) Durable and mechanically cleanable
5) EPA registered anti-microbial agent
6) Certainteed Toughgard R Duct Liner or equal
7) Adhesives
a) Duct Insulation, Internal: Foster 85-60 or equal
b) Weld Pins: Duro-Dyne CP or equal

2. Round Duct Lining; Type RAL
a. Material same as Paragraph 2.3M.1.a
b. Interior air-side surfaces same as Paragraph 2.3M.1.b

c. Self-supporting, slide-in installation
d. JM Permacote Spiracoustic or equal
e. Small diameter ducts which cannot be insulated internally using duct lining materials shall be pre-fabricated. Insulation material shall be fixed between outer duct metal and a perforated metal liner. United McGill k27 series or equal. Fittings shall be insulated to same standard and shall be by same manufacturer.

3. Plenum Lining; Type PL
   a. Material same as Paragraph 2.3M.1.a
   b. Interior air-side surfaces same as Paragraph 2.3M.1.b

PART 3 EXECUTION

3.1 PIPE & EQUIPMENT INSULATION SCHEDULE

A. Insulation Application Types
1. Type P-1
   a. Molded fiberglass
   b. All-service jacket
   c. Vapor-sealed
2. Type P-2
   a. Molded fiberglass
   b. All-service jacket
3. Type P-3: Flexible elastomeric insulation
4. Type P-4
   a. Calcium silicate insulation
   b. Aluminum preformed jacket
5. Type E-1
   a. Fiberglass board
   b. Minimum 3 pounds per cubic foot density
   c. Foil-scrim-kraft facing
   d. Vapor-sealed
6. Type E-2
   a. Fiberglass board
   b. Minimum 3 pounds per cubic foot density
   c. Segmented or scored for curved surfaces
7. Type E-3: Flexible cellular foam insulation

B. Application Schedule

Service	Location	Type	Pipe Size	Thickness
Chilled water piping	General	P-1	All	Per Title 24, 1 inch minimum
Hot water piping	General	P-2	All	Per Title 24, 1.5 inches minimum
Hot water pumps	General	E-2 or E-3		Per Title 24, 2 inches minimum
Hot water coil frame and tube bends	Outdoors, ceiling return air plenum, and unconditioned spaces	E-2 or E-3 or DW-V duct wrap		1/2 inch E-2/3 1.5 inch DW-V

C. Non-insulated piping and equipment
1. Pneumatic tubing

2. Pot feeders and piping to them other than the first 2 feet from the point of connection at piping mains
3. Vent, overflow, drain and relief, except as noted otherwise

3.2 PIPING INSULATION INSTALLATION

A. Install materials in accordance with manufacturer's instructions

B. Coordinate with work of other trades

C. Deliver material to job site in original non-broken factory packaging, labeled with manufacturer's density and thickness

D. Install insulation where it cannot become wet. If insulation becomes wet, remove and dispose of properly and replace with new, dry insulation. Wetted insulation is not acceptable. Ensure insulation is dry before and during installation.

E. Insulate all piping, valves, fittings, flanges and accessories

F. On piping exposed to public view, locate insulation and cover seams in least visible locations

G. Insulate fittings, joints and valves with insulation of same material and thickness as adjoining pipe. Use pre-molded fiberglass fitting covers or radial mitered segments of pipe insulation. For strainers, expansion joints, fittings and accessories requiring servicing or inspection insulation shall be removable and replaceable without damage.

H. Insulate flanges with insulation sleeve of same material as pipe insulation to cover flange and overlap insulation on adjacent piping

I. Continue insulation through walls, sleeves, pipe hangers and other pipe penetrations

J. Finish insulation at supports, protrusions and interruptions. No hangers or supports shall be embedded in insulation. Do not insulate expansion bellows.

K. Fiberglass insulation
1. Provide insulation with factory applied vapor barrier jackets
2. Butt edges neatly. ASJ with 3 inch minimum butt strips
3. Longitudinal overlaps: Minimum 2 inch self sealing, double adhesive
4. Apply additional jacket as specified
5. For piping conveying fluids below ambient temperature finish with vapor barrier adhesive

L. For all pipe systems exposed in the mechanical equipment rooms, finish with an all service jacket

M. For insulation exposed to weather
1. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement.
2. Cover with weatherproof aluminum jacket with seams located on bottom side of horizontal piping. For mechanical joints (such as Victaulic) only, 30 mil UV-resistant PVC fitting covers are acceptable in lieu of aluminum.

N. Perform work at ambient and equipment temperatures as recommended by adhesive manufacture

O. Protection: Protect against dirt, water, chemical, or mechanical damage before, during, and after installation. Repair or replace damaged insulation at no additional cost

P. All vapor barriers shall be continuous. Tears, holes, staples, etc. shall be coated with vapor barrier mastic and patch with facing or tape.

Q. Joints between insulation and access shall be sealed with vapor barrier mastic

3.3 PIPE INSULATION APPLICATION

A. General
1. Before applying insulation
    a. Test piping for tightness and obtain approval
    b. Clean surfaces to be insulated of dust, grease and foreign matter
2. Butt edges neatly
3. Fill voids with insulating cement
4. Longitudinal overlaps
    a. 2 inches minimum
    b. For exposed work: toward ceiling or wall
    c. For weatherproof aluminum jackets: on side to shed water
5. Circumferential overlaps on weatherproof aluminum jackets: 2 inches minimum
6. Continuous insulation passing through sleeves or other openings
7. Oversize insulation to accommodate heat tracing on piping

B. Valves, fittings, flanges and accessory insulation
1. Unless otherwise noted, insulate
    a. Valves including bonnets
    b. Flanges
    c. Fittings
    d. Strainers
    e. Expansion joints
    f. Specialties
2. Insulation for strainers, expansion joints, fittings and accessories requiring servicing or inspection
    a. Insulation removable and replaceable without damage
    b. Enclosed within two piece, No. 18 gauge aluminum covers fastened with cadmium plated bolts and nuts
3. Insulation of same thickness as adjacent piping insulation
4. For piping systems insulated with fiberglass
    a. Wire on pre-molded fiberglass fitting covers or mitered segments of pipe insulation
    b. For pipe sizes under 3 inches, hydraulic setting insulating cement may be used
    c. Vapor barrier for vapor-sealed insulation only
        1) Apply uniform layer of vapor barrier coating to cover entire surface of fitting insulation
        2) Embed layer of fiberglass tape into wet coating, extending 2 inches over adjoining pipe covering
        3) Apply finish layer of vapor barrier coating over entire surface
    d. Finish for exposed locations only
        1) Apply skim coat of insulating cement to smooth out surface of fitting insulation
        2) Embed layer of fiberglass tape into uniform coat of wet mastic, extending 2 inches over adjoining pipe covering
        3) Apply finish coat of same mastic over entire surface of fitting insulation
5. For piping systems insulated with calcium silicate
    a. Wire on pre-molded sections of calcium silicate fitting covers or mitered segments of pipe insulation

b. Under 3 inches pipe size, built up coating of insulating and finishing cement to match thickness of adjoining pipe insulation, may be used
c. For exposed locations only, apply skim coat of finishing cement to smooth out surface of fitting insulation

6. Flanges
a. Insulation sleeve of same material as pipe insulation, to cover flange and overlap insulation on adjacent piping
b. For calcium silicate insulation provide calcium silicate rings between sleeve and pipe insulation

C. At pipe hangers
1. Insulation protection shields specified in Section 230529 Hangers and Supports
2. Butt insulation to shields
3. Cold piping: Wet coat of vapor barrier lap cement on all butt joints

D. Jackets and facings
1. Vapor-sealed types: continuous; staples not permitted
2. Adhere longitudinal laps: Adhere 3 inches wide joint strip, of same material as facing, at center of each butt joint
3. Adhesives
a. Vapor-sealed insulation: vapor-seal adhesive
b. Heating service insulation: vapor-seal adhesive
c. Weatherproof aluminum jacket: sealing compound
d. Underground asphalt felt jacket: asphalt mastic

E. Wiring, banding and fastening devices: Secure insulation to piping and equipment in accordance with following minimum requirements
1. Piping insulation section 3 foot long
a. Concealed vapor-sealed insulation banded at ends and center
b. Other concealed insulation banded at ends and center or stapled on 2 inches centers
2. Pipe fitting insulation
a. Loops of wire to secure mitered segments of insulation
b. Wire spiraled on from end to end on blanket insulation
3. Outdoor piping weatherproof aluminum jackets banded at circumferential joints and center of each section: Lap joint at bottom

3.4 EQUIPMENT INSULATION

A. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with bands, welded-on anchors, ties or adhesive. Where access to equipment is required for testing or maintenance the insulation shall be installed so that it is removable and so that the vapor barrier can be remade after access.

B. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

C. For cold equipment or equipment containing fluids below ambient temperature
1. Insulate entire system
2. Provide vapor barrier jackets, factory applied or field applied
3. Finish with glass cloth and vapor barrier adhesive
4. Cover with aluminum jacket where specified

D. For equipment containing fluids above ambient temperature

1. Insulate entire system
2. Provide standard jackets, with or without vapor barrier, factory applied or field applied
3. Finish with glass cloth and adhesive
4. Cover with aluminum jacket where specified
5. For hot equipment containing fluids 140 degrees Fahrenheit or less, do not insulate flanges and unions, but bevel and seal ends of insulation
6. For hot equipment containing fluids over 140 degrees Fahrenheit, insulate flanges and unions with removable sections and jackets

E. Finish insulation at supports, protrusions, and interruptions

F. For equipment in mechanical equipment rooms or in finished spaces, finish with aluminum jacket

G. Do not insulate over nameplate or ASME stamps; bevel and seal insulation around such

H. General
1. Apply insulation with edges tightly butted
   a. Joints staggered and secured in place by steel bands
   b. Where necessary weld on suitable anchors
2. Seal with 520 adhesive

I. Special considerations
1. Strainers and suction diffusers: removable and replaceable covers to allow strainer removal
2. Pumps: removable and replaceable covers to allow impeller replacement
3. Provide sufficient clearance around openings for normal operation of equipment

3.5 DUCT & PLENUM INSULATION

A. Duct Insulation Type and Thickness Schedule

Location	Cooling or Heat/Cool Supply	Heating-only Supply	Return	Exhaust
Outdoors	2 inches 1.5 pounds per cubic foot AL or RAL	2 inches 1.5 pounds per cubic foot AL or RAL	2 inches 1.5 pounds per cubic foot AL or RAL	–
Concealed in ceiling or return air plenum	1.5 inches DW-V	1.5 inches DW-V	–	–
In unconditioned spaces	1.5 inches DW-V	1.5 inches DW-V	1.5 inches DW-V	–
Exposed within conditioned space	–	–	–	–
In mechanical rooms below 7’0” from floor or otherwise exposed to damage	1.5 inches DB-V	1.5 inches DB	–	–
Lined duct on drawings indicated to have 2 inch liner	2 inches 1.5 pounds per cubic foot AL	2 inches 1.5 pounds per cubic foot AL	2 inches 1.5 pounds per cubic foot AL	2 inches 1.5 pounds per cubic foot AL
Lined duct on drawings (unless otherwise noted)	1 inch 1.5 pounds per cubic foot AL or RAL	1 inch 1.5 pounds per cubic foot AL or RAL	1 inch 1.5 pounds per cubic foot AL or RAL	1 inch 1.5 pounds per cubic foot AL or RAL

Location	Cooling or Heat/Cool Supply	Heating-only Supply	Return	Exhaust
Terminal cans	0.5 inches 1.5 pounds per cubic foot AL	0.5 inches 1.5 pounds per cubic foot AL	0.5 inches 1.5 pounds per cubic foot AL	–
Flex duct	By manufacturer	By manufacturer	By manufacturer	–

B. Non-Insulated Ductwork
   1. No insulation required for ducts so indicated in Duct Insulation Type and Thickness Schedule, plus
      a. Exhaust ducts, unless shown to be lined
      b. Return air ducts in conditioned spaces, unless shown to be lined
      c. Outside air ducts
   2. Do not line ducts
      a. Where prohibited by codes

3.6 DUCT INSULATION INSTALLATION

A. General
   1. Ensure that insulation is continuous through inside walls: See 230548 Vibration and Seismic Control for packing openings through walls
   2. Finish insulation neatly at hangers, supports and other protrusions
   3. Locate insulation joints or cover seams in least visible locations
   4. Where ducts run in groups too close to be individually insulated and finished
      a. Completely fill all spaces between ducts with rigid or flexible insulating material
      b. Insulate and finish exterior surfaces of group as specified for particular service
   5. Where ducts cannot be insulated after erection, insulate prior to installation
   6. Where specified thickness of insulation and/or lining exceeds available thickness in single layer, provide insulation and/or lining in 2 or more layers with joints staggered
   7. Preparation
      a. Do not install covering before ductwork and equipment has been tested and reviewed
      b. Ensure surface is clean and dry prior to installation
      c. Ensure insulation is dry before and during application
   8. Mechanical fasteners
      a. Use spot weld anchors in all shop fabricated internally lined ducts
      b. Adhered anchors
      c. Clip off pin penetrations flush with insulation surface or facing
      d. Seal pins and washers where pins penetrate vapor barriers
         1) With 4 inch square pieces of vapor barrier material to match facing
         2) Adhere with vaporseal adhesive
      e. Spacing on rectangular ducts
         1) Typical of horizontal and vertical, unless otherwise specified
         2) Duct board
            a) 3 inches in from edges
            b) Intermediate fasteners: 12 inches on counter maximum spacing all directions
            c) Not less than four pins per surface
         3) Duct wrap

Side Dimension	Maximum Spacing
24 inches and under	None required.
25 to 32 inches	Horizontal - none.

Side Dimension	Maximum Spacing
	Vertical: 1 row centered, 12 inches on center
33 to 48 inches	2 rows, 12 inches on center.
49 to 60 inches	3 rows, 12 inches on center.
61 inches and over	16 inches on center, all directions.

4) Duct wrap spacing applicable to flat surfaces of flat oval ducts

9. Provide 24 gauge sheet metal Z section frames over edges of duct and plenum lining
    a. At access openings and doors
    b. Along edges exposed to air flow

B. Rectangular Duct Wrap
1. Without vapor barrier
    a. Comply with published recommendations of manufacturer and with following
    b. Secure with 4 inch strips of adhesive, 8 inches on center
    c. For rectangular ducts 24 inches and wider, secure to bottom of duct with mechanical fasteners 18 inches on center
    d. Wrap with 18 gauge galvanized wire, 16 inches on center
2. With Vapor Barrier
    a. Vapor barrier and sealing continuous without breaks. Vapor proof seal around supports and bracing
    b. 2 inches lap strip at one end
    c. Peel insulation for 2 inch lap strip along longitudinal joints
    d. Seal lap strips with vaporseal adhesive; Foster's 85-60 or equal

C. Round Duct Wrap
1. General
    a. Adhere flexible insulation to ductwork with adhesive applied in 6 inch wide strips on 16 inch centers
    b. Provide 16 gauge annealed tie wire tied, spiral wound or half hitched at 16 inch centers
    c. Overlap insulation 2 inches and seal joints and breaks with 2 inch lap of foil adhered over joint
2. Apply duct wrap with vapor barrier as specified above for rectangular ducts

D. Duct Board
1. Comply with published recommendations of manufacturer
2. Secure on top, sides and bottom of duct with mechanical fasteners, spacing as scheduled
3. Secure with 4 inch strips of adhesive, 8 inch on center

E. Rectangular Duct and Plenum Lining
1. Comply with SMACNA Duct Liner Application Standard, published recommendations of manufacturer, and following:
2. Apply adhesive over 100 percent of surfaces to be lined
3. The coated surface shall face air stream
4. Surface adjacent to air flow, including at joints, to be uniformly flat
5. Insulation on floors of plenums and large ducts where access is required shall be protected by wire mesh so that lining is not damaged when walked or crawled on.
6. Blank-Off Panels: Insulation, enclosed with sheet metal on all sides; all joints with vapor barrier mastic and taped
7. Volume Dampers: Where volume dampers do not allow for continuous insulation, terminate insulation clear of handle sweep and finish edges to maintain vapor barrier and to prevent damage to the insulation
8. Seal butt joints and exposed edges of liner to prevent erosion
9. Edges at terminal points shall be provided with metal beading and heavily coated with adhesive

10. Damaged areas replaced or heavily coated with adhesive
11. Mechanical fasteners
    a. Use weld pins
    b. Install mechanical fasteners
        1) Weld pins flush with liner surface. Weld pins spaced maximum of 12-inch on center in both directions and within 2 inches of all corners and joints, except where SMACNA Standard requires closer spacing
        2) Within 2 inches of all edges
        3) Minimum 4 pins per side
        4) For field alterations of lined ducts, install adhesive and glued pins with washers. Clip-off pins after washers installed. Field installed pins shall be used for unusual conditions only and shall not exceed 1 percent of total pins.

3.7 PENETRATIONS THROUGH RATED WALLS

A. Refer to drawings for penetrations of rated assemblies.

B. Install per manufacturer's installation and listing requirements.

3.8 FIELD QUALITY CONTROL

A. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship

B. All vapor barriers shall be continuous; tears, holes, staples, etc. shall be coated with vapor barrier mastic and patch with facing or tape

C. See Section 233100 Ducts for protection of lined duct during construction

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 232113

HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Hot water heating system piping
   2. Chilled water system piping

1.2 REFERENCE STANDARDS

A. ANSI/ARI 710 – Liquid Line Dryers

B. ASTM A53 / A53M - 07 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

C. ASTM F2014-00 Standard Specification for Non-Reinforced Extruded Tee Connections for Piping Applications

D. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

E. ASTM D638 − Tensile Properties of Plastics

F. ASTM D2105 − Longitudinal Tensile Properties of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube

G. ASTM D2143 − Cyclic Pressure Strength of Reinforced, Thermosetting Plastic Pipe

H. ASTM D2412 − Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

I. ASTM D2992 − Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

J. ASTM D3517 − “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe

K. ASTM D3567 − Determining Dimensions of Reinforced Thermosetting Resin Pipe (RTRP) and Fittings

L. ASTM D3681 − Chemical Resistance of Reinforced Thermosetting Resin Pipe in a Deflected Condition

M. ASTM G53 − Weathering of Non-Metallic Materials

N. ANSI/ASME SEC 9 – Welding and Brazing Qualifications

O. ANSI/ASME B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

P. ANSI/ASME B16.26 – Cast Copper Alloy Fittings For Flared Copper Tubes

Q. ANSI/ASME B31.9 − Building Services Piping

R. ANSI/ASTM B32 – Solder Metal

S. ANSI/ASTM B88 – Seamless Copper Water Tube

T. ASTM B280 – Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

U. ANSI/AWS A5.8 – Brazing Filler Metal

V. ANSI/AWS D1.1 – Structural Welding Code

W. AWWA C950 − Fiberglass Pressure Pipe

1.3 QUALITY ASSURANCE

A. Welding materials and labor to conform to ASME Code and applicable state Labor Regulations

B. Use welders fully qualified and licensed by state authorities

C. Welders Certification: In accordance with ANSI/ASME SEC 9 and ANSI/AWS D1.1

D. Each length of pipe, fitting, trap, fixture or device used in any piping system shall be stamped or indelibly marked with
   1. Weight or quality
   2. Maker's name or mark

E. Examine piping layouts and determine requirements for piping offsets, loops or expansion joints to adequately protect systems.
   1. Determine locations and design of anchors and pipe guides to maintain proper piping alignment.
   2. Determine anchor reaction forces and coordinate locations of anchors with Owner's Representative.

F. Coordinate expansion and flexibility requirements of this Section with seismic bracing requirements of Section 230548 Vibration and Seismic Control.

G. Conform to ANSI/ASME B31.9

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Piping materials	R			

Item				
Pipe fittings	R			R
Solder	R2			

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Welding Fittings
1. Babcock and Wilcox Tubular Products Division
2. Bonney Forge Foundry, Inc.
3. Landish Company
4. Taylor Company
5. Tube Turns Division Allegheny International Inc.
6. Or equal

C. Mechanical Couplings and Fittings
1. Victaulic Company of America
2. Grinnell
3. Viega
4. Or equal

D. Flange Gaskets
1. John Crane Company
2. Garlock Mechanical Packing Division
3. Goodrich
4. Manville
5. Or equal

E. Solder
1. Westinghouse
2. J.W. Harris Co., Inc.
3. Handy & Harman
4. Engelhard
5. Lucas Milhaupt
6. Or equal

F. Pipe Joint Compound
1. Rectorseal
2. Permatec
3. John Crane
4. Or equal

2.2 PIPING AND FITTINGS

A. General
1. Piping shall

a. Be commercially round and straight
b. Be of uniform quality and workmanship
c. Be free from all defects
d. Be identified

B. Pressure Piping
1. Pressure piping shall conform to requirements of ANSI Safety Code for Pressure Piping, B31.9
2. Type PP-1: Black Steel
a. Schedule 40 or Standard Weight, ASTM A53 Type E Grade B (electric resistance welded)
b. 2-1/2 inches and larger
c. Welded joints
1) Steel welding-neck fittings, ANSI B16.9-93
2) Steel welding-neck flanges and flanged fittings, ANSI B16.5-88, 150 pounds per square inch
d. Mechanical joints
1) Machined groove or rolled
2) Fittings as hereinafter specified
e. 0.375 inch wall for sizes 12 inch and larger
3. Type PP-2: Galvanized Steel
a. Not used
4. Type PP-3: Copper Tubing
a. ASTM B88; Type M, L or K
b. Hard temper unless indicated otherwise
c. Wrought-copper, solder joint fittings, ANSI B16.22, in sizes available
d. Cast-bronze solder-joint fittings, ANSI B16.18, only in sizes not available in wrought copper
e. Cast-bronze, threaded, ground-joint unions, ANSI B16.15, 2 inches and smaller
f. Cast bronze, flanged unions, ANSI B16.24, 150 pounds per square inch class, 2-1/2 inches and larger
g. Copper tubing flared fittings: bronze castings for flared type joints, ANSI B-16.26
h. Mechanical joints
1) Press-fit
2) Fittings as hereinafter specified

C. Fittings and Flanges: Standard products of respective manufacturer of piping as hereinbefore specified.

D. Flange Gaskets
1. Full faced or flat ring type to suit flange facings, selected from one of following materials
2. Gaskets for flanged joints shall comply with ANSI B16.21
3. Full faced for cast iron flanges
4. Raised face for steel flanges
5. SBR or EPDM, 1/16 inch thick
6. Gaskets coated with thread lubricant when being installed

E. Flange Bolts: Open-hearth bolt steel

F. Unions
1. Steel Piping 2 inches and smaller
a. 250 pounds per square inch: ground joint
b. Equal to Grinnell Fig. 554
2. Steel Piping Larger than 2 inches: Welding flanges
3. Copper Piping: Equal to Nibco No. 633

G. Dielectric Connections
1. Unions

a. Only allowed where union is required elsewhere in specifications or on drawings. Use nipple specified below otherwise.
b. 2 inches and smaller
1) 250 pounds per square inch
2) Standard gaskets for plumbing
3) High temperature gaskets for heating
4) Equal to EPCO Model FX
c. 2-1/2 inches and larger
1) Brass
a) Brass half-union, ANSI B16.1, 1989, 175 pounds per square inch
b) To welding flange as hereinbefore specified
c) Equal to EPCO Model X
2) Copper
a) Half union with EPDM insulator gasket
b) 150 pounds per square inch
c) The Copper component of the flange adapter shall be Third Party Classified by Underwriters Laboratories Inc.

2. Nipples
a. For open circuit hydronic systems:
1) Minimum 4 inch long galvanized steel, stainless steel, brass, or copper nipple with non-conducting thermo-plastic internal lining
2) ASTM Standard F-492 for continuous use at temperatures up to 225°F
3) ClearFlow, Victaulic Style 47 Dielectric Waterway, or equal
b. For closed-circuit hydronic systems: minimum 6 inch long brass nipple

H. Grooved End Fittings and Couplings
1. Fittings
a. Designed for use with grooved- or rolled-end pipe and couplings
b. Materials
1) Steel: ASTM A53 or A106, Grade B
2) Malleable Iron: ASTM A47
3) Ductile Iron: ASTM A536
2. Couplings
a. Mechanical type designed to
1) Engage and lock grooved pipe or fitting ends
2) Form leak-proof joint
3) Allow angular deflection, expansion, contraction, and vibration isolation (flexible type, Victaulic Style 77, Style 177, or equal)
a) Exception: At contractor's option and risk, rigid couplings (Victaulic Style 107 or equal) may be used except at the following locations:
1. Mechanical equipment connections where the couplings are being used in lieu of flexible coupling for vibration isolation
2. Risers, for which we use flexible couplings for expansion and contraction
3. Straight horizontal runs over 20 feet long, for which we use flexible couplings for expansion and contraction
b. Housings
1) Malleable Iron: ASTM A47
2) Ductile or Nodular Iron
c. Gaskets
1) EPDM
2) Materials required for specific service, minimum 230°F operating temperature
3) Product of coupling manufacturer
d. Bolts and Nuts
1) Track-head or oval neck type bolts

2) Standard hexagon nuts
3) Heat treated carbon steel conforming to ASTM A183
4) Minimum tensile strength: 110,000 pounds per square inch

3. Pressure Ratings
   a. 3/4 inch to 6 inches: 1000 pounds per square inch
   b. 8 to 12 inches: 800 pounds per square inch
   c. 14 to 24 inches: 300 pounds per square inch
4. Finish
   a. Painted
5. Equal to Victaulic Company of America

I. Press-Fit Fittings and Couplings
1. For ½" to 4" copper piping
2. Smart Connect feature to provide clear visual indication of which connections have not been pressed prior to putting the system into operation
3. EPDM sealing element suitable for application
4. Listings and certifications
   a. NSF-61-372
   b. IAPMO PS 117
   c. UL 213
   d. FM Class 1920
   e. ABS 1.1.2
5. Compliant with:
   a. California Mechanical Code
   b. California Plumbing Code
   c. NFPA 13, 13D and 13R
6. Operating ranges
   a. 0°F to 250°F
   b. 200 psi
7. Equal to Viega ProPress

2.3 PIPING SPECIALTIES

A. See Section 232114 Piping Specialties

2.4 SOLDER

A. S-1: Silfos or Silvaloy 15 silver solder (brazing) with 15 percent silver, 80 percent copper and 5 percent phosphorous

B. S-1A: Safety Silv 56 cadmium-free silver solder (brazing) with 55 to 57 percent silver, 21 -23 percent copper, 15 to 19 percent zinc, 4 to 6 percent tin, and 0.15 percent other metals.

C. S-2: 95 percent tin 5 percent antimony solder, lead free, or

D. S-2A: 95.6 percent tin, 4 percent copper, 0.4 percent silver, lead free

PART 3 EXECUTION

3.1 PIPE SERVICES

A. Piping type shall be in accordance with the table below. Where multiple types are listed, any may be used at Contractor's option.

Service	Location	Type of Pipe	Remarks
Hot water Chilled water	Above ground	PP-1; PP-3 Type L	

3.2 INSTALLATION

A. Coordinate with work of other trades.

B. Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leak resistant piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes where indicated by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance.

C. Arrangement
1. Except for large scale details piping is diagrammatically indicated. Install generally as shown.
2. Do not scale drawings for exact location of piping.
3. Install piping to best suit field conditions, in coordination with other trades.
4. Piping Arrangement
   a. Arrange piping neatly along walls
   b. In neat, horizontal groups
   c. Each group to be in one plane, insofar as possible
   d. Maintain required slope
5. Do not sleeve structural members without consent of Owner's Representative.
6. Maintain minimum l inch clearance from adjacent work, including insulation, except as noted.
7. Install piping concealed above ceilings or in walls unless otherwise indicated.
8. Installation of piping shall be made with use of appropriate fittings. Bending of piping will not be allowed.
9. Unions installed shall be accessible.
10. Locate piping runs vertically and horizontally; avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. In finished and occupied spaces, conceal piping from view by locating in column enclosures, in hollow wall construction, or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated.
11. Electrical equipment spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless the piping serves equipment in the room.
12. Use tapered reducers where any change in pipe size occurs. Bushings shall not be used.
13. Conceal piping in finished portions of building, above the floor line. Cutting of walls and floors shall be held to the minimum possible to secure the proper installation.
14. Provide concealed high points with air chambers with 1/4-inch copper tube vent line and stop cock carried to accessible point.
15. Install piping subject to expansion or contraction in a manner permitting strains to be evenly distributed and alleviated.
16. Pipe the discharge of each relief valve, air vent, backflow preventer, and similar device to floor sink or drain.
17. Pipe coils with inlet at bottom, outlet from top, unless otherwise directed by coil manufacturer.

D. Penetrations
1. Escutcheons

a. Provide stainless steel escutcheons at piping penetrations of walls that are exposed public view and required for proper appearance. Provide galvanized steel escutcheons at penetrations of masonry walls elsewhere.
   1) Clearance from duct to opening shall not exceed 1 inch.
   2) Escutcheons shall overlap wall, floor, or ceiling surface by ½ inch minimum.
b. Escutcheons are not required at drywall penetrations where not exposed to public view.

2. Caulk and seal all piping penetrations through acoustical walls and partitions. See Section 230548 Vibration and Seismic Control.

1. Firestopping at penetrations of fire rated floors and partitions
   a. The fire-resistance rating of penetrations and fire-resistant joint systems shall be firestopped with a UL listed firestop system that will maintain the fire rating of the assembly. Through-penetrations and membrane penetrations shall be protected by an approved system installed as required by the system listing or as otherwise permitted by CBC Section 714. Listed through-penetration firestop systems and membrane penetrations shall be installed in accordance with the installation details for the listed system to be installed. Fire protection system installation details and listings shall be submitted for approval prior to the start of system installation.
   b. Manufacturer
      1) 3M Penetration Sealing Systems (PSS 7909) and 3M Fire Barrier Caulk and Putty
      2) Dow-Corning LTV Silicone foam
      3) Or equal
2. At all below-grade penetrations, provide mechanical seal complete with wall sleeve with wall anchor, and water stop plate. Seals shall be modular mechanical type, consisting of interlocking synthetic rubber links shaped to fill the annular space between pipe and sleeve, complete with pressure plates and cadmium plated nuts and bolts.

E. Sloping, Air Venting and Draining
1. Slope piping as indicated, true to line and grade, and free of traps and air pockets.
2. Reducers/increasers
   a. Eccentric
      1) At pump suction where reducer is required
      2) Top side flat
   b. Concentric: All other locations
3. Connect branch piping to bottom of mains in closed systems.
4. Provide drain valves and hose adapters as indicated on drawings and at the bottom of all risers.
5. Vents: See Section 230523 Valves.

F. Piping Specialties: See Section 232114 Piping Specialties.

G. Pipe Hanging and Supports: See Section 230529 Hangers and Supports.

H. Flashing and Sleeves: See Section 230529 Hangers and Supports.

I. Painting: See Section 230501 Basic Mechanical Materials and Methods.

J. Pipe Identification: See Section 230553 Mechanical Identification

K. Copper
1. Crimping of copper tubing prohibited.
2. Isolate copper tubing from ferrous materials and hangers with two thicknesses of 1 inch wide 10 mil polyvinyl tape, spiral-wrapped around pipe. Total width shall be a minimum of 3 inches.

L. Coatings: Reapply coal-tar coating on buried piping, after installation, to surfaces from which coating has been removed or scraped.

M. Care of Floors
1. Do not set pipe vises or threading machines on unprotected concrete floors.
2. Cover floor when making plumbing connections to avoid staining floors with oil, white or red lead or other substances.
3. Remove any stains at no additional cost to the Owner.

3.3 COPPER AND STEEL WATER PIPING

A. Fittings
1. Provide standard, manufacturing fittings in all cases.
2. Prohibited fittings
   a. Field fabricated
   b. Bushings on pressure piping
   c. Clamp-on branch connections
3. Provide insulating couplings or dielectric unions at all connections of ferrous piping to non-ferrous piping.
4. Branch connections, steel piping
   a. Equal to main and to two pipe sizes smaller: Weld tees, same weight as piping
   b. Three or more pipe sizes smaller than main, but 2-1/2 inches and larger: Bonney Weld-o-lets
   c. Two inches and smaller: Bonney Weld-o-lets, or steel couplings
5. Branch connections, copper piping
   a. Seamless tee or
   b. Press-fit tee or
   c. Mechanically formed tee connection
      1) ASTM Designation F2014-00
      2) Per ASME B31.9 Section 930.2
      3) Equal to T-Drill T-D35

B. Provide unions or flanges to render all items in systems easily removable, including
1. Control valves
2. Both sides of pumps and equipment
3. Where indicated on drawings
4. Use mechanical (Victaulic) couplings at all connections on tube-pull side of chiller to allow for temporary removal of piping to provide full access to the water box for tube pull.
5. Exceptions
   a. Copper water piping 1-inch or less, at Contractor's options, since the copper can be easily cut and the union is a less secure joint than a soldered joint
   b. Unions not allowed:
      1) Where not allowed by code

C. Pipe Ends
1. Perform pipe cutting and end preparation to result in clean ends with full inside diameter
2. Grind and ream as necessary

D. Nipples
1. Close nipples not permitted.
2. Provide extra heavy pipe for nipples where unthreaded portion is less than 1-1/2 inch long.

E. Threaded Joints: Not allowed other than unions and accessories (e.g. gauges, test plugs)

F. Welded Joints

1. Welded joints shall not be substituted for mechanical (Victaulic) joints where mechanical joints are specifically called out in specifications or on Drawings (for example to provide expansion/contraction or chiller tube pull access).
2. Weld pipe joints in accordance with recognized industry practice and as follows
    a. Welding shall be done by qualified welders in a first-class, workmanlike manner, conforming to the American Standard Code for Pressure Piping USA B-31.1 and B-31.1A.
    b. Bevel pipe ends at a 37.5 degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
    c. Do not weld-out piping system imperfections by tack-welding procedures; re-fabricate to comply with requirements.
    d. Standards: Conform to Section UI, Chapter 4, "Welding of Pipe Joints", ANSI B31.9 and applicable portion of ASME Boiler and Pressure Vessel Code, Section IX.
    e. Operator's qualifications: All welders engaged in work under this Section shall be qualified in accordance with State requirements. Each operator's certificate shall be on file at site and made available to State upon request. Welding of pressure piping shall be done by-welders who have been qualified by recognized agency within 6 months prior to date of Contract.
    f. Preparation for welding: Bevel piping on both ends before welding; both ends shall have 1-1/6 inch land at bottom of bevel. Pipe with a 3/4 inch wall thickness or less shall be beveled to a standard 37.5 degrees.
    g. Use backing rings on all butt-welding joints 6-inches and larger.
    h. State employed Inspector will visually inspect welds. Any weld judged defective by visual inspection shall be cut out and tested in presence of Inspector. If percentage of defective coupons is deemed excessive, contractor shall cut additional coupons as directed by the Owner's Representative or the State Inspector. Removal and replacement of test coupons and samplings shall be done at no additional cost to the Owner. At the option of the State Inspector or the Owner's Representative, certain welds may be required to be radiographed.
3. Where required, peen and wheel-grind welds.
4. Ends of pipe may be burned for welding
    a. Grind bevel and remove scale between welding joint.
    b. Ragged edges with metal beads, poor alignment other inferior work will be rejected.
5. Perform welding with oxyacetylene or electric arc process.

G. Grooved and Rolled-End Joints
1. Perform following in accordance with manufacturer's instructions
    a. Cut or roll pipe
    b. Install couplings and fittings
2. Determine that gasket material and lubricant are compatible with service of pipe.

H. Press-Fit Joints
1. Use only on above-ground applications.
2. Strictly comply with manufacturer's instructions and recommendations.
3. Pressure test with water
    a. First test for any unpressed fittings using a pressure range of 15 psig to 85 psig.
    b. Once all fittings are confirmed to be pressed, pressure test as required herein and per code.

I. Soldered and Brazed Joints
1. Solder
    a. Use Solder S-1 for
        1) Mechanically formed tee connection (T-drill)
    b. Use Solder S-1 or S-2A for
        1) Piping 3 inch and larger
    c. Use Solder S-2 or S-2A other than above.
2. Clean surfaces to be jointed, of oil, grease, rust and oxides

a. Remove grease from fittings by washing in solution of 1/16 sodium carbonate and three gallons hot water (except as otherwise specified for medical gas piping)
b. Clean socket of fitting and end of pipe thoroughly with emery cloth to remove rust and oxides.
c. Wipe excess solder from joint before it hardens.

3. When soldering or brazing materials that could be damaged by heat, remove sensitive parts and protect parts from heat. Joints shall be cool before reassembling.
4. Cut tubing square, reamed, and burrs removed.
5. Prevent annealing of fittings and tubing when making connections.

3.4 EXPANSION CONTROL

A. General
1. Install piping to permit free expansion and contraction without damaging piping or construction.
2. Provide offsets, expansion loops, anchors, guides and supports to permit expansion, within stress limits of ANSI 31.1 Pressure Piping for temperature ranges specified.
3. Where pipe loops or changes in direction of piping cannot be employed to absorb expansion and contraction, provide expansion joints.
4. Install pipe guides so that movement takes place along axis of pipe only. Pipe moves laterally at expansion elbows.
5. Make riser offsets in manner to avoid pocket forming due to expansion.

B. Expansion Calculations
1. Thermal Expansion
a. Determine thermal linear expansion of each segment of piping systems.
b. Base expansion calculations on following temperatures, plus 30 percent safety factor
1) Hot Water Heating
a) Idle temperature: 50 degrees Fahrenheit
b) Maximum temperature: 210 degrees Fahrenheit
2) Chilled Water
a) Operating temperature: 40 degrees Fahrenheit
b) Maximum temperature: 100 degrees Fahrenheit
c. Determine effect of linear expansion upon piping layout in building
1) If resulting stresses exceed maximum allowable limits introduce additional loops and/or offsets.
2) Where space limitations preclude installation of loops and/or offsets provide expansion joints.
2. Structural Considerations
a. Install pipe anchors to provide required restraints on expanding piping systems.
b. Install pipe guides to provide required restraints against lateral action of expanding piping systems
1) Spacing for expansion joints: per manufacturer's recommendations.
2) Spacing for pipe loops and/or offsets: as required to maintain alignment within allowable stress limits.
c. Locate anchors and guides only at building structural members capable of taking imposed reaction loads.
d. Determine horizontal and vertical reaction loads of anchors and guides to building structure
1) Coordinate details and reaction loads with structural engineer for building.
2) If necessary, revise location and number of anchors and guides as recommended by structural engineer to result in allowable reaction loads to building.

C. Provision for Expansion
1. Loops, bends, offsets

a. As indicated or because of job required relocation of piping and equipment.
b. Design as follows
1) Use spring type loop U-bend or offset U-bend.
2) Corner radii five to six times pipe diameters.
3) Join bends only by welding
a) Welding-steel piping
b) Brazing-copper or bronze piping

2. Mechanical Joint System
a. Grooved- or rolled-joint piping systems with provisions for expansion control methods incorporating inherent flexibility of couplings and fittings may be provided, under conditions specified below
1) Submit design considerations published by manufacturer of couplings and fittings.
2) Conditions specified below must comply with published design considerations.
3) Rolled-joint piping expansion accommodation is generally less than for grooved-joint systems. Verify sufficient joints are provided.
b. Perform calculations as specified elsewhere in this section, along with determining any other data required to assure that longitudinal motion, angular deflection and resultant forces do not exceed recommendations in manufacturer's design considerations.
c. Provide required anchors and guides spaced per manufacturer's design considerations.
d. Install with gap settings of all couplings and fittings to permit full range of expansion, contraction and/or angular deflection as recommended by manufacturer to take place without excessive displacement and forces.

3. See Section 230548 Vibration and Seismic Control

3.5 TESTING

A. Test of Water Piping
1. Test water piping at completion of roughing in, in accordance with the following schedule and show no loss in pressure or visible leaks after a minimum duration of four hours, or time as indicated, at the test pressures indicated.
2. Make connections to existing CUP systems with flanged connection. During testing of the new work, provide a slip-in plate to restrict test pressure to new systems only. Remove plate and complete connection to existing system at completion of testing.
3. Inspect pressure piping in accordance with procedures of ANSI B31.
4. Hydrostatic test pressure
a. Less than 100 psi operating pressure: 150 psi
b. Over 100 psi operating pressure: 1-1/2 times operating pressure
c. Never exceed test pressure ANSI B16.1 basis
5. Duration: 2 hours
6. With system valves capped and pressure apparatus disconnected
a. Pressure change: none
b. Compensate for temperature change
7. Leaks and defects
a. Repair or replace as directed by the Owner’s Representative
b. At no additional cost to the Owner
8. Notify Owner’s Representative in writing one week before test.
9. Furnish written report and certification that tests have been satisfactorily completed to the Owner’s Representative.

3.6 WATER PIPING SYSTEM CLEANING

A. During Construction

1. Keep openings in piping closed to prevent entrance of foreign matter
2. Clean pipe, fittings and valves internally
3. Hammer welds to remove slag and weld beads

B. Cleaning Procedure
1. Cleaning shall be supervised by water treatment supplier. See Section 232500 Water Treatment. When approved, procedure below may be modified based on recommendations of supplier.
2. Clean system immediately after pressure test.
3. Protect against damage from freeze up or discharge of water.
4. Closed Circuit Piping Systems
   a. Open all valves (including control valves) in all legs so circulation goes through all sections.
      1) For 3-way valves, either set to 50% open position or begin procedure with valves full open to coil and change to full open to bypass halfway through cleaning period.
   b. Install temporary filter bags or fine-mesh start-up strainer screen in all line strainers during cleaning.
   c. Fill with clean water.
   d. Keep return isolation valve separating the building from the campus loop closed to prevent startup debris from migrating back to the central plant; crack open supply isolation valve to provide a thermal expansion/contraction path for the mass of water in the building loop (applies after each loop filling). Bypass startup valve shall be open throughout cleaning procedure and closed immediately thereafter.
   e. Start pumps and operate at design flow rate or greater. On chilled water system without pumps, provide a temporary pump at taps provided; flow rate per water treatment specialist's recommendations.
   f. Simultaneously drain at low points and fill the loop until effluent is clear.
   g. Shut off makeup water.
   h. Circulate for a minimum of two 48-hour periods. For each period:
      1) Add alkaline detergent via pot feeder. See Section 232500 Water Treatment.
      2) At end of period
         a) Shut the supply isolation valve.
         b) Remove and clean strainers.
         c) Drain at low points.
   i. After last circulation period
      1) Shut off pumps.
      2) Shut the supply isolation valve.
      3) Completely drain out entire system of cleaning solution.
      4) Remove filters at strainers, or replace start-up screen with final strainer screen.
      5) Fill system with clean water.
      6) Start pumps, and simultaneously drain at low points for 8 hours.
      7) Test
         a) Alkalinity not more than 200 parts per million in excess of alkalinity of rinsing water
         b) Effluent visually clear; no visible particles or color
      8) Repeat flushing of water until tests are met.
   j. Should any pipe be plugged, disconnect piping, clean again, and reconnect at no additional cost to the Owner.
   k. Connect the building to the campus distribution network.
      1) Open both the supply and return isolation valves to place the building into service.
      2) Start building pumps at 60 Hz and circulate water for a duration coordinated with the campus' water treatment provider to ensure that treated water from the central plant is distributed throughout the building. Thereafter, release the control valves and building pumps to automatic control.
      3) Coordinate start of service with campus engineering so that central plant chemical dosing can be adjusted, if needed, to account for the fluid volume added by the building.
      4) Do NOT leave the system filled with untreated water for more than 4 hours.

5. All open circuit systems shall be flushed until water runs clean.

3.7 COMPLETION REQUIREMENTS

A. Complete Pre-Functional Test Data Sheet for each hydronic system. See Section 230800 Mechanical Commissioning.

END OF SECTION

SECTION 232114

PIPING SPECIALTIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Escutcheons
   2. Bypass chemical feeders
   3. Strainers
   4. Thermometers
   5. Pressure gauges
   6. Test plugs

1.2 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Escutcheons	R2			
Bypass chemical feeders	R			R
Strainers	R			
Thermometers	R	R		
Pressure gages	R	R		
Test plugs	R			

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Bypass chemical feeders
   1. J. L. Wingert Co.
   2. Industrial Chemical Corporation
   3. Or equal

C. Strainers
   1. C.M. Bailey

2. Mueller
3. Keckley
4. Victaulic
5. Or equal

D. Thermometers
1. Weksler
2. Weiss Instruments, Inc.
3. Ashcroft
4. Trevice
5. Marsh
6. Or equal

E. Pressure gauges
1. Weksler
2. Weiss Instruments, Inc.
3. Dresser Industries, Ashcroft
4. H. O. Trerice Company
5. Or equal

F. Pressure-temperature test plugs
1. Peterson Engineering Company
2. Taco, Inc.
3. Or equal

2.2 ESCUTCHEONS

A. Provide escutcheons with inside diameter closely fitting pipe outside diameter or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, ceilings, or pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish and screw or spring clamping device with concealed hinge.
1. Pipe escutcheons for moist areas: For water resistant floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged. Split hinged type shall not be used in areas with security requirements.
2. Pipe escutcheons for dry areas: Provide sheet steel escutcheons, solid or split hinged. Split hinged type shall not be used in areas with security requirements.

2.3 BYPASS CHEMICAL FEEDER

A. Batch feeder for closed circulating water systems

B. Capacity: 5 gallons

C. Steel shell and heads

D. Cap: Cast iron with Buna N "O" ring: Quarter-turn to open

E. 3/4 inch tappings for water in and out and drain

F. Operating pressure and temperature
1. Minimum rated operating pressure up to 125 pounds per square inch

2. Minimum rated operating temperature up to 250ºF
3. Design and installation as indicated

G. Wingert Model HD or equal

2.4 STRAINERS

A. Pressure rating: minimum 150 psi at 200°F

B. Screen
1. 304 or 316 stainless steel or Monel, reinforced
2. Free area not less than 3 times inlet area
3. Perforations
   a. To 2 inch: 20 mesh
   b. To 4 inch: 1/16 inch
   c. 5 inch and larger: 1/8 inch

C. Y-Type
1. 2 inches and less
   a. Cast Bronze
   b. Solder joint
   c. Bronze cap and plug, straight thread with composition gasket
   d. Keckley E-150 or equal
2. Larger than 2 inches
   a. Cast iron
   b. Flanged connection
   c. Bolted cast iron cover with composition gasket and threaded hose connection
   d. Keckley Style A or equal

D. Basket type
1. Cast iron
2. Flanged connection
3. Bolted cover, bottom or side drain connection
4. Keckley Style GFV or equal

E. Provide Hubbell, Refrigerant Specialties, or equal on refrigeration systems.

2.5 THERMOMETERS

A. Digital, self-powered
1. Display: Minimum 3/8" LCD digits, swivel mount for 360º viewing adjustment
2. Range: 0 to 300ºF
3. Sensor: Glass passivated thermistor
4. Accuracy: 1% of reading or 1ºF, whichever is greater
5. Resolution: 0.1 ºF between 0 and 200ºF
6. Recalibration: Internal potentiometer
7. Lux Rating: 10 Lux (one foot-candle)
8. Waterproof cover for outdoor installations
9. Ambient Operating Range:
   a. Temperature: -30/140°F
   b. Humidity: 0% RH to non-condensing
10. Power: Self-powered via integral photovoltaic cells

11. Weiss DVU, Weksler AD, or equal

B. Stem Length for Nominal Pipe Sizes
1. Below 4 inch: 3-1/2 inch stem, elbow mounted
2. 4-8 inch: 3-1/2 inch stem
3. 10-14 inch: 6 inch stem

2.6 PRESSURE GAUGES

A. Pipe or equipment mounted type
1. Diameter: 4 1/2 inch, except as noted
2. Case: black finished cast aluminum with flangeless back
3. Threaded black cast aluminum ring with gasketed glass face
4. Type 316 stainless steel spring tube
5. Stainless steel precision movement: Micrometer adjustment on needle
6. Accuracy: 0.5 percent full scale range
7. With calibration adjustment
8. Quarter turn stop cock: Materials compatible with service
9. Pressure snubbers
   a. Filter type
   b. For liquid, air and gas
10. Weksler Type AA44 or equal

B. Pressure gauge ranges in pounds per square inch gauge
1. Heating water pump: 0-100
2. Pressure gauges indicated on drawings or in specifications not indicated above to be submitted with appropriate range for review

2.7 PRESSURE/TEMPERATURE TEST PLUG

A. Solid brass with valve core

B. Valve core: Nordel or EPDM

C. Fitted with a color coded and marked cap with gasket

D. Suitable for 500 pounds per square inch gage and 275ºF for water systems

E. Pete's Plug: No. 110 with yellow cap or equal

2.8 FLANGES

A. Convoluted

B. Carbon steel, cold-formed

C. Weld-neck and blind flanges in conformance with the design criteria of Section VIII, Division I of the ASME Pressure Valve Code

D. Flanges drilled and tapped to match ANSI 150

E. All material to comply with requirements of ASTM A516

F. Gaskets: Teflon or as recommended by the flange manufacturer and suitable for the service involved

G. Slip-on flanges will not be permitted

H. 150-pound and 300-pound weld-neck and screwed steel flanges on steel lines to conform to ANSI Standard B16.5 for dimensions and ASTM A 181 Material Standard

PART 3 EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturer's instructions.

3.2 ESCUTCHEONS

A. Install at piping penetrations of walls, floors and ceilings
   1. Where exposed to public view
   2. At penetrations of exterior walls

B. Where piping is insulated, escutcheons shall fit insulation outside diameter.

3.3 BYPASS CHEMICAL FEEDERS

A. Install feeder in convenient location where it may be easily refilled, maximum 4 feet above floor.

B. Install as indicated on drawings
   1. Support from floor
   2. Valves on inlet, outlet and drain

3.4 STRAINERS

A. Wye-type: Where shown on drawings and ahead of all automatic balancing valves and pressure regulating valves

B. Basket-type strainers: Where shown on drawings

C. Install strainers in horizontal or vertical-down position

3.5 INSTRUMENTATION

A. Install sensors and sensor wells to piping using thread-o-lets welded or soldered to pipe, or other approved means. For piping smaller than 1.5 times well depth, wells shall be installed in the end of an elbow, or tee used in place of an elbow, to minimize obstruction.

B. Thermometers

1. Install thermometers for easy readability (height, distance, view angle) from floor wherever possible.
2. Install in brass or stainless steel thermowell.
3. Locate where shown on drawings.

C. Pressure Gauges
1. Provide gauges where shown on drawings.
2. Install gauges on non-vibrating backing.
3. Provide instrument cocks for isolation and removal of gauge at each pressure connection point.
4. Install gauges for easy readability (height, distance, view angle) from floor, except gauges at ceiling coils
5. At pumps, install a single pressure gauge only piped to pump taps at the inlet and outlet of pump. Using two gauges or connecting to piping rather than pump taps is not acceptable.

D. Pressure-Temperature Test Plugs
1. Provide pressure/temperature test plugs where shown on drawings.
2. Also locate at all temperature and pressure sensors for calibration, see Section 250000 Building Automation Systems.
3. Mount using threadolet welded or braised to pipe.

3.6 INSPECTION

A. Verify that adequate clearance between piping specialties and adjacent walls or equipment is available to permit maintenance and repairs.

3.7 TESTING AND ADJUSTING

A. Test thermometers, pressure gauges and water meters for accurate indication with known calibrated master; calibrate or replace if not within 5 percent of reading.

B. Test air vent points to insure all air has been vented.

C. Test other piping specialties for proper operation.

D. See Section 230800 Mechanical Commissioning.

END OF SECTION

SECTION 232123

PUMPS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for all water pumps except
   1. Where integral with manufactured piece of equipment
   2. Where specialty pumps applicable to specific systems are specified under the relevant Section

1.2 REFERENCE STANDARDS

A. Underwriters' Laboratories, Inc.: UL 778 – Motor Operated Water Pumps

B. American Society of Mechanical Engineers: ASME Section VIII – Boiler and Pressure Vessel Code – Pressure Vessels

C. ANSI/HI Pump Standards

1.3 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Pump data	R	R		R
Mounting details				R

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Bell and Gossett

C. PACO

D. Patterson

E. Or equal

2.2 GENERAL

A. Centrifugal, single stage, unless otherwise noted

B. Bronze fitted (impeller and wear rings)

C. Statically and dynamically balance rotating parts

D. Construction to permit complete servicing without breaking piping connections

E. Pumps to operate at 1750 rpm unless specified otherwise

F. Bearings: Grease lubricated roller or ball bearings

G. Shaft seals
1. Mechanical, internally flushed
2. Single, inside mounted, end face rubber bellows type
3. Springs: stainless steel
4. Seal head: brass or stainless steel
5. Carbon face rotating against a stationary ceramic face
6. Elastomer: Buna or EPDM

H. Substitutions
1. Brake horsepower rating at design conditions shall be no more than 10 percent above that scheduled.
2. Motor horsepower shall be no larger than that scheduled, or compensate Division 26 contractor for any associated cost to increasing motor size.

I. Motors: See pump schedule and Section 230513 Motors and Controllers

J. Pump characteristics
1. Pump curve shall rise continuously from maximum capacity to shutoff
2. Shutoff head approximately 10 percent greater than design head
3. Operation between 65% and 115% of GPM at best efficiency point (BEP) for the indicated impeller size, ideally between 85% and 105% of GPM at BEP
4. For pumps serving variable flow (2-way valve) systems; or where multiple pumps operate in parallel other than lead/standby applications
    a. Pump shall be capable of operating at 40 percent beyond design flow rate without exceeding break off point
    b. Motors shall be selected for non-overloading operation at a flow rate 40 percent beyond design flow rate
5. Impeller diameter
    a. Minimum tip to cutwater clearance: 4%
    b. Constant speed pumps: Trim to duty
    c. Variable speed pumps: Trim to the maximum impeller size that does not cause an increase in motor size (so that maximum efficiency is achieved).

K. Pumps and flanges tested and rated to withstand 1-1/2 times specified working pressures based on both inlet pressures scheduled and pump shut-off head or 175 pounds per square inch working pressure at 250 degrees Fahrenheit, whichever is greater.

L. Pumps to be suitable for handling fluids at scheduled temperatures

M. Pressure taps on both inlet and outlet for gauge connection mounted in the pump casing (not in external piping)

N. Factory tested

O. Painted with at least one coat of high-grade machinery enamel

2.3 IN-LINE

A. Type as scheduled
   1. Close coupled
   2. Suitable for vertical or horizontal operation
   3. Back pullout design

B. Shaft: Stainless or Carbon Steel

C. Wearing rings: renewable bronze

D. Shaft sleeves: bronze

E. Casing with suction and discharge gauge ports, vent and plugged drain ports

F. Capable of being serviced without disturbing piping connections

G. Pump volute base ring tapped for 1-1/2 inch 125 pound ANSI flange to support pump

H. Pump flanges to have 125 pound ANSI flange drilling

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades

B. Install pump in accordance with manufacturer's written installation instructions

C. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer

D. Decrease to pump suction from line size with flat-top eccentric reducers on horizontal inlet piping (or suction diffuser where indicated on drawings), concentric reducers elsewhere

E. Support piping adjacent to pump such that no weight is carried on pump casings

F. Allow at least 5 pipe diameters between pump suction entry and closest elbow or strainer, unless a pump suction diffuser is installed

G. Inlet and discharge valves and other piping specialties shall be pipe size, not pump inlet or discharge connection size

H. See Section 232114 Piping Specialties

I. See Section 250000 Building Automation Systems

J. See Section 230800 Mechanical Commissioning

3.2 MOUNTING AND ALIGNMENT

A. See Section 230548 Vibration and Seismic Control

B. Recheck alignment after operation when the pump and the driver are at operating temperature.

3.3 INSPECTION

A. Verify that adequate clearance between pump and adjacent walls or equipment is available to permit maintenance and repairs.

B. Check that pump is suspended from building structure and not supported by piping.

3.4 PRE-OPERATING CHECKS

A. Before operating pumps
1. See Section 019100 Commissioning
2. Complete the attached Pre-Functional Test Data Sheet, Appendix 232123 A, for each pump
3. Assure that piping is clear of debris which might clog pump
4. Vent air from pump system to assure water in pump and piping system
5. Check for proper and sufficient lubrication
6. Check for correct operation of check valve
7. Check for correct rotation
8. Confirm alignment again after grouting has properly set and re-align if required
9. Check packing nut adjustment for proper leakage rate and packing lubrication
10. Assure that strainer is clean before commencing testing
11. Check for proper adjustment of vibration isolation

3.5 TESTING AND ADJUSTING

A. Before starting pump: See Section 019100 Commissioning

B. After starting pumps
1. Check for high bearing temperatures
2. Check temperature of packing gland or mechanical seal for proper cooling operation
3. Check for motor overload by taking ampere reading at maximum operating conditions, i.e. all valves open and individual pump running
4. Check shut-off head to ensure impellers properly trimmed

C. See Section 230593 Testing, Adjusting, and Balancing

D. See Section 230800 Mechanical Commissioning

3.6 TRAINING

A. See Section 230800 Mechanical Commissioning

B. Engage a factory-authorized service representative to train Owner's maintenance personnel on:
   1. Procedures for starting and stopping and troubleshooting pumps
   2. Procedures and schedules for maintaining and servicing pumps
   3. Organization and content of Operations & Maintenance Manuals

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 233100

DUCTS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Ductwork
   2. Single wall plenum walls and casings
   3. Fasteners and Sealants
   4. Exceptions: Where integral with manufactured piece of equipment

1.2 REFERENCE STANDARDS

A. SMACNA HVAC Duct Construction Standards, latest edition

1.3 DEFINITIONS

A. Seam: locks or weld applied longitudinally to close section of duct, for example longitudinal seam, spiral seam.

B. Joint: abutting connection between duct sections for continuity of air passage, for example cross joint, transverse joint, coupling.

C. Reinforcement: hardware applied to strengthen duct, for example girth angles, tie rods, fasteners (not connectors), and the like.

D. Stiffening: folding, bending, beading, cross-breaking or corrugating of sheets to achieve strength through shape, for example pocket lock secures joint and is transverse stiffener, with girth angle and fasteners applied (not connectors), joint or stiffener is reinforced.

E. Duct Classification
   1. Terms used in this specification are defined as follows:
      a. Low Pressure: less than 2 inches pressure class and less than 2000 feet per minute air velocity
      b. Medium Pressure: 2 inches to 6 inches pressure class or higher than 2000 feet per minute air velocity
      c. High Pressure: above 6 inches pressure class

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. “R” means required.

2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Ductwork materials and fittings	R			R
Flexible ducts	R			R
Duct sealants	R			
Duct pressure testing reports		R		

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Spiral oval and round ducts
1. United Sheet Metal Division, United McGill
2. Semco Manufacturing, Inc.
3. Metco
4. Contractor fabricated
5. Or equal

C. Duct Connection Systems
1. Ductmate Industries, Inc.
2. Fabriduct Transverse Duct Connection system
3. Ward Industries, Inc.
4. Or equal

D. Flexible Ducts
1. Thermaflex
2. Flexmaster
3. Or equal

E. Duct Sealants
1. Minnesota Mining and Manufacturing Company
2. Foster
3. Childers
4. Miracle Adhesive Corporation
5. United Sheet Metal Division United McGill Corporation
6. Hardcast Products Group
7. Mon Eco Industries
8. Nashua
9. 3M
10. Or equal

F. Flexible Duct Clamps
1. Panduit
2. Aeroquip Corporation
3. Ideal Division Parker Hannifin Corporation
4. Tridon Corporation
5. Young Regulator Company

6. Or equal

G. Duct Support Systems
1. CEAS Wedgy Support Systems
2. Gripple
3. Or equal

2.2 MATERIALS

A. Galvanized Steel Sheet Metal
1. Cold rolled soft steel sheets
2. ASTM A653 and A924
3. Galvanizing:
   a. General: minimum G-60
   b. Exposed to weather or outdoor air, or as indicated herein or on Drawings: minimum G-90
   c. Plenum walls and blank-offs where in contact with cooling coil: minimum G-90
4. Lock-forming quality

B. Miscellaneous Products
1. Screws and rivets
   a. Same material as sheet, except as indicated on the Drawings
   b. On aluminum sheets, provide cadmium plated or stainless steel
   c. Zinc or cadmium plated, permitted on galvanized sheets
   d. Minimum screw size: No. 10
   e. Minimum rivet size: 4 pound
2. Duct Sealants
   a. Duct Sealing Compound. UL-181 listed, water-based
      1) Foster Safetee Duct Sealant 32-19
      2) Childers CP-146
      3) Design Polymerics DP-1010
      4) Hardcast Products Group Flex-Grip 550 or 601
      5) Or equal
   b. Rolled Elastomeric Duct Sealant: Hardcast Products Group Foil-Grip 1403-181BFX, Aluma-Grip AFT-701 or equal, UL-181 listed
   c. Gaskets
      1) Continuous, reinforced, inert self-conforming type
      2) 1/8 inch thick
      3) Width: to match angle connection.
      4) 3M Weatherban Ribbon Sealant PF5422 or equal
   d. Two-Part Hard-Setting Joint Tape
      1) Two part process includes tape and hard setting sealant
      2) Mineral impregnated woven fiber tape
      3) Impregnated with activator/adhesive of polyvinyl acetate type
      4) UL Listed
      5) Flame spread: 10
      6) Smoke contributed: 0
      7) Equal to Hardcast 550 or 601 sealant and Aluma-Grip AFT-701 tape
3. Spring Fasteners
   a. Oval head stud and receptacle
   b. Screwdriver slot
   c. Self-ejecting
   d. Dzus or equal

4. Angles, tie rod and shapes for reinforcing ducts: In accordance with SMACNA HVAC Duct Construction Standards
5. Duct connection system
    a. Transverse bolted duct joints
    b. Flanges with permanent, non-hardening sealant
    c. Ductmate Industries Ductmate 25 and 35, Fabriduct TDC, or equal

C. Turning vanes
1. Galvanized steel ductwork: galvanized steel or painted black steel, except as indicated on the Drawings
2. Other ductwork: same material as ductwork
3. Construction per SMACNA HVAC Duct Construction Standards for
    a. Single wall vanes with 3/4 inch trailing edge
    b. Double wall vanes: Not acceptable
    c. Vane length: Provide separate equal size sections for vane length greater than those indicated in referenced Standards.
    d. Vane runners: Type 1 or 2 acceptable
4. Vane radius
    a. 2 inch radius: duct width up to 36 inches
    b. 4 inch radius: duct width 36 inches or larger
5. Vanes shall be at the correct angle for airflow (leading edge in line with the entering duct section; leaving edge in line with exiting duct section). If only 45º angles are available, turning vanes shall only be used in 90º elbows where the entering width equals the exiting width; all other elbows shall be full radius type unless otherwise indicated on the drawings.

D. Low pressure round duct take-off fittings in rectangular duct
1. Factory-fabricated spin-in fitting
2. Die-formed galvanized steel
3. Balancing damper
    a. Spring loaded
    b. Locking regulator
    c. Sealed at both ends to prevent leakage
4. No scoop allowed for any application
5. Noll Manufacturing, Young Manufacturing or equal

2.3 ROUND AND OVAL DUCTWORK

A. General
1. Construction
    a. Factory- or shop-fabricated spiral lock seam duct; no snap lock
    b. Factory-fabricated longitudinal seam
        1) Acceptable for ducts larger than standard factory sizes
        2) Welded duct
2. Fittings
    a. Same material and construction as duct in which installed
    b. For ductwork exposed to occupant view, do not use fabricated fitting at taps to VAV boxes and outlets. Instead use saddle tap cut into continuous spiral duct. Intent is for spiral duct to be continuous for aesthetic reasons. Saddle tap flange width shall be 0.5 inches or less.
    c. Tees and taps
        1) 45 degree conical or shoe tap
        2) 90 degree conical tap
            a) Inlet diameter shall be minimum 2 inches wider than the round duct diameter
            b) Maximum 14º taper angle

3) 90 degree straight tap

d. Elbows
   1) Seams
      a) Spot welded with bonded seams or spiral seam except as indicated below
      b) Continuous welded seams for the following applications
         1. 4 inch and higher pressure class
         2. Product conveying ducts such as those for grease exhaust and laboratory fume hood exhaust
         3. Dishwasher exhaust for horizontal ducts
         4. Where exposed to occupant view
      c) Adjustable elbows with sealed gores are acceptable on low pressure ducts where concealed from occupant view
   2) Minimum gores as follows:
      a) 2 gores - less than or equal to 30 degrees
      b) 3 gores - 31 degrees through 45 degrees
      c) 4 gores - 46 degrees through 60 degrees
      d) 5 gores (or solid full radius) - over 61 degrees
   3) Throat radius to diameter ratio shall not be less than 1.0 except:
      a) Where shown otherwise on Drawings
      b) Short radius adjustable elbows with sealed gores are acceptable on low pressure ducts where concealed from occupant view

2.4 FLEXIBLE DUCTS

A. Flexible ducts
   1. UL 181, Class I Air Duct
      a. Products categorized as only Flexible Air Connectors under UL 181 are prohibited.
   2. Labeled for compliance with CMC
   3. Minimum working pressure
      a. 2 to 4 inch positive static pressure class: 4 inches
      b. 0 to 1 inch negative static pressure class: 1 inch
   4. Insulated Flexible Duct
      a. Chlorinated polyethylene (CPE) inner liner duct permanently bonded to a vinyl or zinc coated spring steel wire helix
      b. Fiberglass insulating blanket; minimum R-value
         1) Ducts outside the conditioned space and in conditioned envelope: 4.2
         2) Ducts outside conditioned space and conditioned envelope: 8.0
      c. Low permeability outer vapor barrier of fiberglass bi-directional reinforced metallized film laminate
      d. Inner and outer liners shall provide a double air seal
      e. Minimum Insertion Loss, 10 feet straight duct, 2500 fpm

Duct ID (in.)	Frequency (Hz)						
	125	250	500	1000	2000	4000	8000
6	11	33	37	39	37	19	14
8	13	35	34	39	29	17	14
≥12	10	26	26	35	24	11	9

      f. Warranty: free of defects in material and factory workmanship for a period of 10 years from the date of manufacture
      g. Thermaflex M-KE or equal
   5. Uninsulated Flexible Duct
      a. Woven fiberglass fabric with flame retardant coating permanently bonded to a vinyl or zinc coated spring steel wire helix

b. Thermaflex S-LP-10 or equal

B. Flexible ductwork clamps
1. Straps listed for use with flexible ductwork
2. 2 inches and greater SP Class: Galvanized steel strap
   a. Adjustable toggle type
   b. Young Quick-Clamps or equal
3. Less than 2 inches SP class: Adjustable nylon strap
   a. With factory furnished installed tool
   b. Panduit PAN-TY Cable Ties, Heat Stabilized Nylon 6/6

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades

B. See Division 25 Building Automation Systems

C. See Section 230800 Mechanical Commissioning

3.2 MOUNTING AND ALIGNMENT

A. See Section 230548 Vibration and Seismic Control

3.3 DUCT CLASSIFICATION

A. Minimum operating pressure for each duct system, general
1. Scheduled static pressure for each fan or unit, positive or negative, unless otherwise indicated on the Drawings
2. Adjust upward to nearest pressure class tabulated in SMACNA HVAC Duct Construction Standards

B. Static pressure class, unless otherwise indicated on the Drawings

Application	**SMACNA Pressure Class**
VAV supply air duct and risers from AHU thru shaft fire/smoke damper	3 inches
Other VAV supply air duct upstream of VAV boxes	2 inches
Downstream of VAV boxes, fan-coils, heat pumps, SZ VAV etc.	1 inch
Outdoor air	-2 inches
Toilet exhaust	-2 inches
Other fans systems	Per fan static
Return air transfers	1/2 inch

3.4 DUCTWORK INSTALLATION

A. General

1. Install ducts in accordance with manufacturer's written installation instructions
2. Construct with gages, joints, bracing, reinforcing, and other details per current CMC and SMACNA, unless specified otherwise
    a. Comply with most stringent
    b. Provide ducts with CMC gages or thicker when traversing rated corridors
    c. Combustion air ducts: Minimum 24 gage
3. Construct of galvanized sheet metal, except where otherwise indicated herein or on Drawings
4. Provide for duct rigidity by either of these methods
    a. Beading at 12 inches on center, maximum
    b. Crossbreak outward in ducts having positive internal pressure
    c. Crossbreak inward in ducts having negative internal pressure
        1) Exception: All ducts exposed to rain shall outward crossbreak on top of the duct.
5. Duct dimensions indicated are outside duct dimensions (OD) unless indicated on the Drawings as inside dimension (ID or net, clear dimension).
6. Alter duct sizes on basis of equal friction where required to facilitate installation. Reflect changes in shop drawings for review by Owner's Representative.
7. At duct penetrations of walls, floors and ceilings where exposed to occupant view, provide sheet metal angle type escutcheons with no sharp corners or edges.
    a. Clearance from duct to opening shall not exceed 2 inches.
    b. Escutcheons shall overlap wall, floor, or ceiling surface by ½ inch minimum.
8. Frame, trim, caulk and seal all duct penetrations through acoustical walls and partitions. See Section 230548 Vibration and Seismic Control.
9. Firestopping at penetrations of fire rated floors and partitions
    a. The fire-resistance rating of penetrations and fire-resistant joint systems shall be firestopped with a UL listed firestop system that will maintain the fire rating of the assembly. Through-penetrations and membrane penetrations shall be protected by an approved system installed as required by the system listing or as otherwise permitted by CBC Section 714. Listed through-penetration firestop systems and membrane penetrations shall be installed in accordance with the installation details for the listed system to be installed. Fire protection system installation details and listings shall be submitted for approval prior to the start of system installation.
    b. Manufacturer
        1) 3M Penetration Sealing Systems (PSS 7909) and 3M Fire Barrier Caulk and Putty
        2) Dow-Corning LTV Silicone foam
        3) Or equal
10. Tapers
    a. Pitch sides of duct in diverging or converging airflow maximum of 1 to 4 taper
    b. Abrupt, bushing type fitting not allowed
11. Duct openings
    a. Provide openings where required to accommodate thermometers, smoke detectors, controllers, and the like. Insert through airtight rubber grommets.
    b. Where openings are provided in insulated ductwork for insertion of instruments, install insulation material inside metal ring for use as plug.
    c. At fire dampers allow adequate length of duct to install access door.
12. Avoid penetration of ducts; provide airtight seal at unavoidable penetrations of hanger rods and tie rods.
13. No exposed sharp metal allowed
    a. All exposed pins, screws and sharp objects shall be covered with hardening silicon
    b. All exposed sheet metal edges shall be hemmed with exposed corners rounded smooth
    c. Remove all sheet metal fish hooks
    d. Dryer ducts shall have no screws or other elements protruding into ducts that might catch lint.
14. Install lining in ducts and plenums as specified in Section 230700 Mechanical Insulation.
15. Volume dampers: Install dampers as specified in Section 233300 Duct Accessories
16. Ducts exposed to occupant view

a. Use only spiral round or oval ducts; no rectangular duct or flex duct unless specifically shown on Drawings.
b. Use Gripple hangers.
c. Duct sealant shall be clear and concealed in the joint, invisible to occupants.
d. Run ducts parallel to the structure unless specifically shown on Drawings.
e. Ducts shall not intersect wall corners or run parallel to and within a full height wall.
f. Where painting is shown on architectural drawings, materials shall be de-greased or otherwise ready to paint (paint by others).
g. Ducts shall have no external markings or tags.
h. Saddle taps and other taps to grilles, tees, wyes, etc.:
    1) Have flanges at duct connection inside the duct concealed from view
    2) Do not break the duct, i.e. use taps cut into a continuous spiral duct, not factory constructed tees.

B. Rectangular Elbows
1. Use radius elbows in rectangular ducts unless otherwise indicated on the Drawings based on ratio of inner throat radius (R) to duct width in plane of radius (W):
    a. Low pressure: R/W shall not be less than 0.5
    b. Medium pressure: R/W shall not be less than 1.0
    c. Where space does not permit radius specified above, install short radius splitter vanes per SMACNA HVAC Duct Construction Standard with number of splitter vanes determined by R/W ratio
        1) One vane: R/W above 0.3
        2) Two vanes: R/W between 0.1 to 0.3
        3) Three vanes: R/W 0.1 and smaller
2. Square turns with turning vanes in rectangular ductwork may only be used as follows:
    a. Where shown on drawings. Note: turning vanes are not required on return air transfer boots unless shown on Drawings.
    b. Where radius elbow specified above cannot fit.
    c. Where close to inlets at fans (to minimize system effect).

C. Rectangular ductwork
1. Transverse Joints
    a. Standard: Fabriduct TDC or Ductmate or equal. Low pressure ductwork may be slip & drive (S&D) per SMACNA.
    b. Welded. Where indicated herein or on plans.
2. Longitudinal Joints
    a. Standard: Pittsburgh. Snap lock not allowed.
    b. Welded. Where indicated herein or on plans.
3. Branch take-offs
    a. Medium pressure riser taps: double 45 degree (upstream and downstream)
    b. Other medium pressure: 45 degree upstream
    c. Low pressure: straight 90 degrees

D. Plenum walls, blank-offs, and casings
1. Constructed per SMACNA HVAC Duct Construction Standard, Casings and Plenums.
2. Static pressure class
    a. Upstream of fan: -2 inches
    b. Downstream of fan: fan static pressure or greater
3. Seal all joints, edges, and penetrations as per HVAC ducts as specified herein.

E. Round and oval ductwork
1. Joints
    a. Standard: Beaded sleeve joints mechanically fastened with sheet metal screws or pop rivets

b. Welded. Where indicated herein or on plans.

2. Longitudinal
   a. Standard: Spiral lock
   b. Welded. Where indicated herein or on plans.
3. Branch take-offs
   a. Medium pressure: 45 degrees or conical 90 degrees
   b. Low pressure: straight 90 degrees. Branch connections may be made with spin-in fittings
   c. Center-line take-off, unless otherwise indicated on the Drawings

F. Flexible ductwork
1. Use only where shown on drawings.
2. Type:
   a. Insulated acoustical type shall be used for all:
      1) Supply air
      2) Return air
      3) Exhaust air (for acoustical dampening) except rooms with showers or other high moisture sources
   b. Uninsulated type shall be used for all:
      1) Exhaust air from rooms with showers or other high moisture sources
3. Not allowed for:
   a. Product conveying systems such as kitchen exhaust and laboratory exhaust
   b. Dishwasher exhaust
   c. Dryer exhaust (other than final exposed connection at dryer)
   d. Medium pressure ducts upstream of VAV boxes
4. Continuous, single pieces
5. Length
   a. Maximum: 5 feet
   b. Minimum:
      1) Insulated acoustical type: 5 feet
      2) Uninsulated type: 3 feet
6. End Connections
   a. Connect to duct collars, terminal unit connections and round air outlets per manufacturer's instructions.
   b. Secure with strap clamps and seal as specified herein.
7. Installation
   a. Support adequately to avoid excessive droop
   b. Minimum inside bending radius not less than one duct diameter
   c. Install as straight as possible except as shown on drawings for sound attenuation
   d. Cut ducts to lengths required rather than create bends to take up excess lengths except as shown on drawings for sound attenuation

G. Grille connections
1. Provide at entry to diffuser collar either
   a. Straight duct for 1 duct diameters or greater
   b. Full radius elbow
   c. Side inlet plenum
      1) Height: 4 inches minimum taller than top of grille to provide room for uniform airflow to grille
      2) Width/length: 2 inches wider than duct or round diffuser collar, whichever is larger
      3) For supply air grilles, internal surfaces lined with minimum 1/2 inch thick Type AL duct liner as specified under Section 230700 Mechanical Insulation
      4) At contractor’s option, where plenum is required at round neck diffuser, square neck diffuser with length and width equal to diffuser diameter may be substituted
   d. Thermaflex FlexFlow Elbow or equal

2. Connections at grilles shall be insulated to the extent the duct is insulated including the final register box.
3. Seal connections at grilles per seal class of upstream ductwork.

H. Duct hangers and supports
1. General
   a. Support horizontal ducts with hangers of size and spacing as indicated in pertinent SMACNA HVAC Duct Construction Standards
   b. Attachment to structure: See Section 230529 Hangers and Supports
   c. Seismic restraints: See Section 230548 Vibration and Seismic Control
2. Horizontal Duct Supports
   a. Install hangers at each change in direction of duct
   b. Strap hangers
      1) Extend strap down both sides of ducts
      2) Turn under bottom one inch minimum
      3) Metal screw hangers to
         a) Bottom of duct
         b) Upper and lower sides of ducts
         c) Not more than 12 inches on center
   c. Angle hangers
      1) Provide angle hangers formed by extended vertical bracing angles
      2) Or by rods connecting to bottom angles if size or bracing angles conform to hanger schedule
3. Vertical duct supports
   a. Support vertical ducts at every floor
   b. Use angles or channels mechanically fastened to ducts with screws or pop rivets.
   c. Set angles or channels on floor slab or structural steel members placed in opening, unless otherwise indicated on the Drawings

I. General ductwork
1. Applies to ductwork not specifically listed in Paragraphs below
2. Standard galvanized construction
3. Standard seams and joints

J. Ducts exposed to weather
1. Galvanized steel G-90, 304 stainless steel, or aluminum
2. Make ducts subject to rain watertight.
3. Construct as follows to assure water run-off
   a. Arrange standing seams to not act as dams
   b. Longitudinal seams at bottom of duct
   c. Construct all ducts subject to rain watertight and to insure water runoff by one or more of following techniques
      1) Slope entire top of duct down toward side
      2) Vertical struts within duct to bow top panels of duct into convex shape
      3) Sheet metal cap where shown on Drawings

K. Sound-rated duct packing
1. Wherever possible avoid duct penetrations through sound-rated walls, floors and ceilings.
2. Provide packing for unavoidable duct penetrations per Section 230548 Vibration and Seismic Control.

L. Joint Sealing
1. Seal ducts per the Seal Levels tables below

a. Seal factory fabricated ducts and plenums, including terminal boxes, if not factory sealed to Seal Level listed
b. Provide more stringent sealing if required to meet requirements of Paragraph 3.5.

Seal Level Requirement				
Duct Location	Duct Type			
	Supply		Exhaust/ outdoor air	Return
	<2 in. water column[b]	≥2 in. water column[b]		
Outdoors	A	A	C	A
Unconditioned Spaces	A	A	C	A
Return Air Plenums	A	A	A	C
Conditioned Spaces	C	A	A	C

[b] Duct design static pressure classification.

Seal Level Definitions	
Seal Level	Sealing Requirements
A	All transverse joints, longitudinal seams, and duct wall penetrations
B	All transverse joints and longitudinal seams
C	Transverse joints only

Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod or wire. Spiral lock seams in round and flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps and other branch connections, access door frames and jambs, duct connections to equipment, gores of elbows, etc.

2. Ducts not exposed to weather
   a. General: Seal using one of the following:
      1) Duct Sealing Compound
      2) Gasketed TDC or Duct-Mate
      3) Two-Part Hard-Setting Joint Tape
      4) Rolled Elastomeric Duct Sealant if and only if
         a) Joint is not exposed to occupant view
         b) Pressure class is less than 2 inches
         c) Surface is clean, dry, and grease/oil-free
         d) Extensive pressure is applied, working the tape into the duct surface using an application tool recommended by the Rolled Elastomeric Duct Sealant manufacturer.
   b. Flexible duct
      1) Secure with straps or clamps as specified herein.
      2) Supplement with Rolled Elastomeric Duct Sealant, both inner and outer liner.
   c. Indoor duct where exposed to occupant view: Sealant shall be within joint only and not visible.
   d. Fire and fire/smoke dampers: Sealant shall be listed as SFM approved on manufacturer's UL installation sheet.
   e. Continuous welded ducts: Additional sealing not required.
3. Duct exposed to weather
   a. TDC or Duct-Mate joints: Utilize interior joint gasket material plus a bead of butyl rubber sealant at the joint and continuous metal clip or cleat over the top of all four joints (top bottom and sides).
   b. Continuous welded ducts: Additional sealing not required.
   c. Other joints: Apply Two-Part Hard-Setting Joint Tape to
      1) Longitudinal joints
      2) Transverse joints

3) Duct penetrations
4) Screws through duct
5) Gores of elbows

4. After installation and testing reseal joints found to be leaking at no additional cost to the Owner.

3.5 DUCT PRESSURE/LEAKAGE TESTING

A. Scope of Testing
1. HVAC Ductwork and Plenums
a. Supply
1) 3-inch pressure class and greater: Test entire duct section.
2) 2-inch pressure class:
a) Required only if duct area required to be tested by other sections herein do not total 10% of the total installed duct area for the project.
b) Test 2-inch class duct sections starting with those that are directly connected to 3-inch pressure class ducts until 10% of the total installed duct area for the project. Provide a drawing showing proposed sections to be tested for approval prior to testing.
3) Ductwork outside the building envelope: Test entire duct section.
4) Other: Not required
b. Return:
1) Ductwork outside the building envelope: Test entire duct section
2) Other: Not required
c. Exhaust:
1) General: Not required
d. Outdoor air: Not required
2. Life Safety Ductwork
a. Since smoke exhaust will be balanced at the atrium exhaust per Section 230593 Testing, Adjusting and Balancing, leakage in the mechanical room is not relevant. Relief fans have been oversized to account for some mechanical room leakage.

B. General
1. Tests conducted in presence of Owner's Representative
2. Use portable high pressure blower and necessary instruments to indicate amount of leakage
3. See Section 230593 Testing, Adjusting and Balancing for testing procedures and accuracy of test instruments
4. Conduct tests as prescribed in SMACNA HVAC Air Duct Leakage Test Manual, and make test before duct sections are concealed
5. Procedure
a. Seal openings in ducts and plenums to be tested.
b. Connect test apparatus to test section using flexible duct connection or hose.
c. Close damper on blower suction side, to prevent excessive buildup of pressure.
d. Start blower and gradually open damper on suction side of blower.
e. Build up pressure in test section equal to static pressure class.
f. Noise generated from duct leakage not acceptable. Seal as required.
g. Determine amount of air leakage by makeup air flow measurements:
1) Maximum permitted leakage for HVAC ductwork shall be:

$$CFM_{max} = (A/100)\, C_L\, P^{0.65}$$

where

CFM_{max} = the maximum permitted leakage, cubic feet per minute (cfm).
A = surface area of the tested duct sections, square feet.
CL = duct leakage class, cfm/100 square feet at 1 inch water column.

= 6 for rectangular sheet metal, rectangular fibrous ducts, and round flexible ducts
= 3 for round/flat oval sheet metal or fibrous glass ducts
P = test pressure which shall be equal to the design duct pressure class rating, inches water column.

2) Maximum permitted leakage for life safety ductwork shall be per CBC 909.
3) If leakage exceeds allowable limit, and only a portion of the ductwork was tested per Paragraph 3.5A.1.a.2), repair leaks and retest duct sections until permitted leakage limits are obtained, then expand testing to include 40% of duct system area at no additional cost to the Owner. If failures continue, expand to 100% of duct system area at no additional cost to the Owner.

6. Visually mark tested sections with certification sticker and initials of field test inspector.

C. Documentation
1. Submit certification of test results of compliance to Commissioning Authority.
2. Include certified test results showing compliance per Section 230501 Basic Mechanical Materials and Methods.

3.6 PROTECTION

A. Adhere to SMACNA Duct Cleanliness for New Construction Guidelines for Intermediate Level Duct Cleanliness unless more stringent requirements are indicated herein.

B. Storage: Porous materials, such as lined and flexible duct, shall be stored where they will not be exposed to rain or other moisture sources.

C. Temporary closure: Provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris at the following conditions:
1. Exposed ends of unlined installed ducts at the end of each day
2. Exposed ends of lined ducts or plenums whether in storage or installed

D. Duct cleaning
1. Using the connected fan(s) force air at high velocity through duct to remove accumulated dust
2. Protect equipment and spaces, which may be harmed by excessive dirt with filters, or bypass during cleaning
3. In areas, which must be kept dust free, seal all outlets duct tight. When closures are removed avoid spilling dust in room

3.7 INSPECTION

A. Verify that adequate clearance between ducts and adjacent walls or equipment is available to permit proper sealing, maintenance and repairs.

3.8 PRE-OPERATING CHECKS

A. Before operating the duct systems: Set all manual dampers in full open position

B. Complete the Pre-Functional Test Data Sheet (Section 230800 HVAC Commissioning) for each duct system.

3.9 TESTING AND ADJUSTING

A. Before starting the duct systems
   1. Clean the duct system. See Paragraph 3.6D
   2. See Section 019100 Commissioning

B. After starting the duct systems: Check for noise and leakage. Repair as required at no additional cost to the Owner.

C. See Section 230593 Testing, Adjusting, and Balancing: Coordination with Balance Agency:
   1. Provide services of a sheet metal installer familiar with the system ductwork to provide assistance to the balancing agency during the initial phases of air balancing in locating all sheet metal dampers
   2. Install missing dampers

D. See Section 230800 Mechanical Commissioning

END OF SECTION

SECTION 233300

DUCT ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Access Doors
   2. Balancing Dampers
   3. Automatic Dampers
   4. Backdraft Dampers
   5. Fire Dampers
   6. Smoke Dampers
   7. Fire/Smoke Dampers
   8. Sound Attenuators
   9. All duct accessories except, where integral with manufactured piece of equipment.

1.2 QUALITY ASSURANCE

A. Fire, smoke, and fire/smoke dampers shall be UL listed and constructed in accordance with UL Standard 555 Fire Dampers and UL Standard 555S.

B. Demonstrate operation of smoke dampers to authorities having jurisdiction and Owner's representative as part of life safety testing.

C. Access doors shall be UL labeled.

D. Damper pressure drop and leakage ratings shall be based on tests and procedures performed in accordance with AMCA 500 - Test Methods for Louvers, Dampers and Shutters.

1.3 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Access doors	R2			R
Balancing dampers	R2			R
Automatic dampers	R	R		R
Backdraft dampers	R2			R
Fire dampers	R	R		R
Smoke dampers	R	R		R

Item				
Fire/Smoke dampers	R	R		R
Sound attenuators	R			R

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Access Doors, Ducts
1. Ventfabrics, Inc.
2. Duo Dyne, Corporation
3. Ruskin Mfg. Company
4. PCI Industries – Pottorff
5. Ductmate
6. Or equal

C. Access Doors, Plenum
1. Ventfabrics, Inc.
2. Duo Dyne, Corporation
3. Elgen Manufacturing Company
4. Or equal

D. Balancing and Automatic Dampers
1. Ruskin Manufacturing Company
2. Greenheck
3. Air Balance Inc.
4. American Warming and Ventilating Inc.
5. Johnson Controls
6. PCI Industries - Pottorff
7. Or equal

E. Backdraft Dampers
1. Greenheck Fan Corp
2. Ruskin Manufacturing Company
3. Air Balance, Inc.
4. American Warming and Ventilating Inc.
5. Or equal

F. Damper Hardware
1. Ventfabrics, Inc.
2. Duo Dyne, Corporation
3. Young Regulator Company
4. Or equal

G. Fire Dampers and Combination Smoke and Fire Dampers
1. Ruskin Manufacturing Company
2. Greenheck
3. Air Balance Inc.

4. PCI Industries - Pottorff
5. Or equal

H. Sound Attenuators
1. Vibro-Acoustics
2. Dynasonics
3. Industrial Acoustics, Inc.
4. Or equal

2.2 DUCT ACCESS DOORS

A. In accordance with SMACNA Duct Construction Manuals, except as indicated in the Drawings

B. In Ductwork

1. Construction

a. Same material as duct

b. Rating same as duct pressure class

c. Where duct is insulated

1) Fiberglass insulation, thickness to match duct insulation installed R-value, see 230700 Mechanical Insulation

2) Double wall

d. Positive seal polyethylene gasket

e. Paired progressive cam-locks, quantity as required for tight, low leakage fit

f. No tools required for opening and closing

2. Size

a. 20 inches x 14 inches unless otherwise indicated in the Drawings

b. Ducts less than 16 inches: one dimension 20 inches; other dimension 2 inch less than duct width

c. Larger sizes where required for access

C. In Grease and Lab Exhaust Ductwork
1. Factory fabricated access doors listed for application
2. Size as shown on drawings and per code

2.3 DAMPERS

A. Volume Dampers
1. Conform to requirements of SMACNA HVAC Duct Construction Standards.

2. General
    a. Blades of same material as duct where damper is located
    b. Damper Hardware
        1) Ventlok 400 and 4000 series or equal; for low pressure systems 2 inch SMACNA pressure class and less
        2) Ventlok HiVel hardware or equal; for greater than 2 inch SMACNA pressure class
    c. Actuating quadrants typical for single and multi-blade dampers; provide closed bearing on opposite end from quadrant to prevent air leakage: Ventlok No. 609 or equal
    d. Bearing at one end of damper rod: Ventlok No. 609 or equal
    e. Sealed bushings installed at both ends to avoid duct leakage
    f. Accessible quadrant at other end of damper rod
        1) With lever and lock screw: Ventlok No. 635 or equal
        2) Insulated ducts
            a) Quadrants mounted on collar to clear insulation
            b) Ventlok Nos. 637, 638, or 639 or equal
            c) Selection based on insulation thickness
    g. For volume dampers above non-removable (inaccessible) ceilings
        1) Use ceiling access panels if provided for another purpose and located within reach of the damper; do not provide access panels whose sole purpose is for damper access.
        2) Otherwise provide either:
            a) Ventlok No. 677, MAT Roto-Twist 200, or equal mechanical concealed damper regulator with
                1. Required interconnecting hardware and cable
            b) Greenheck RBDR-50, MAT Electro-Balance 200 or equal electrically actuated balancing damper assembly (position feedback not required) with
                1. Required interconnecting hardware and cable
                2. Battery powered controller
            c) With either device, controller connection shall be located in a concealed location as follows:
                1. In the diffuser/grille backpan or plenum where accessible through the diffuser/grille
                2. Above the ceiling at the terminal box that serves the damper. This may be a ganged connector for multiple dampers served by the terminal box.
                3. Above the ceiling at the nearest accessible location, such as next to a fire/smoke damper ceiling access panel
3. Single blade dampers
    a. Galvanized steel ductwork: galvanized steel, except as indicated in the Drawings
    b. Blade: Two gages heavier than duct gage, or 18 gage, whichever is lighter
4. Multi-blade Dampers
    a. Low Pressure/Low Velocity Systems (2 inch water column or less static pressure class and 1500 fpm or less face velocity)
        1) Opposed blade damper
        2) Ruskin Model CD35 or equal
    b. High Pressure/High Velocity Systems (greater than 2 inch water column static pressure class or greater than 1500 fpm face velocity):
        1) Rectangular
            a) Opposed blade damper
            b) Ruskin Model CD60 or equal
        2) Round and Oval
            a) Oval: Ruskin Model CDR25 and DO25 or equal
            b) Round: Up to 20 inch diameter: Ruskin Model MDRS25 or equal
            c) Round: Larger than 20 inch diameter: Ruskin Model CDRS25 or equal

B. Automatic Dampers

1. Refer to Section 237300 Air Handling Units for dampers provided with factory packaged air handling equipment.
2. Field installed dampers
    a. Blade Action
        1) Throttling duty: opposed
        2) Mixing duty: parallel
        3) Two-position: parallel or opposed
    b. Bearings: Molded synthetic or stainless steel sleeve, turning in extruded hole in frame.
    c. Seals:
        1) Blade: Inflatable PVC coated fiberglass material, silicone, or neoprene mechanically attached to blade edge.
        2) Jamb: Flexible metal compression type.
    d. Linkage: concealed in frame. External linkage, jump-over brackets, jackshafts and any other elements in the airstream will not be accepted.
    e. Axles: Minimum 1/2 inch diameter plated steel, hex-shaped, mechanically attached to blade. Side access for direct-coupled actuator.
    f. Finish: Mill galvanized
    g. Where stainless steel dampers are indicated on drawings, dampers shall have stainless steel blades, stainless steel bearings, stainless steel jamb seals.
    h. Where aluminum dampers are indicated on drawings, dampers shall have aluminum blades, aluminum frame, synthetic or stainless steel bearings, stainless steel jamb seals.
3. Actuators: Direct coupled type specified under Division 25 Building Automation Systems
4. Damper area: See Drawings.
5. Damper type: See Drawings.

C. Backdraft Dampers
1. Required locations
    a. Where indicated on the Drawings
    b. In suction or discharge of all exhaust fans as listed in equipment schedule
        1) Integral, heavy-duty factory-installed type acceptable unless otherwise scheduled
2. General Applications
    a. Construction
        1) Extruded aluminum construction, minimum 4 inch 12 gage frame
        2) Extruded vinyl locked into blade edge.
        3) Blade ends overlapping frame
    b. Performance
        1) Start to open: .02 inches w.g. or less
        2) Fully open: .05 inches w.g. or less
        3) Leakage for 24 inch wide damper: 25 cfm per ft^2 or less
    c. Ruskin Series CBD4 or equal
3. High Velocity Applications
    a. Applies to discharge of air handlers and where velocity exceeds 1500 fpm. Damper shall be specifically designed for location at turbulent fan discharge.
    b. Frame
        1) Minimum 12 gage galvanized steel channel
        2) Bolt Holes: Both flanges
    c. Blades
        1) Airfoil-shaped with integral structural reinforcing tube running full length of each blade
        2) Material: 7 inches x minimum 0.080 inch Alloy 6063-T5 extruded aluminum
        3) For multiple section dampers, provide galvanized steel or aluminum bracket to link dampers so they operate together.
    d. Axles: Minimum 3/4 inch (19 mm) diameter plated steel
    e. Bearings: Bolt-on bearings with re-lube ball bearings
    f. Linkage

1) 3/16 inch thick x 3/4 inch plated steel tie bar with minimum 16 gage plated steel linkage arms; stainless steel pivot pins
2) Located out of airstream (side or external linkage)

g. Counterbalance: Located out of airstream

h. Seals
1) Blade
a) Mechanically attach blade seals to blade
b) Silicone rubber, rated for 300 degrees Fahrenheit
2) Jamb: Vinyl

i. Ruskin CBS92 or equal

j. For Fume Hood Exhaust Fans only
1) As above except stainless steel blades, stainless steel bearings, stainless steel linkage and axles, silicone blade edge seals, and no jamb seals.
2) Greenheck HB-230 or equal

2.4 FIRE DAMPERS

A. Ratings (test conditions and label) per UL Standard 555
1. 250 degrees Fahrenheit minimum
2. 1-1/2 hour fire rating, unless otherwise indicated in the Drawings
3. Dynamic (closes against air flow) where required by code or where scheduled

B. Factory sleeve

C. Damper
1. Multi-bladed, equipped with fusible link, spring loaded type

D. Fusible link
1. UL listed
2. Fusible links on fire dampers shall be constructed to UL Standard 33 – Fusible Links for Fire Protection Service
3. Temperature rating: Per code

E. Type: as indicated on the Drawings

2.5 COMBINATION FIRE AND SMOKE DAMPERS

A. Fire ratings (test conditions and label) per UL Standard 555S
1. 250 degrees Fahrenheit minimum
2. 1-1/2 hour fire rating, unless otherwise indicated in the Drawings

B. Factory sleeve

C. Damper
1. Either parallel blade or opposed blade
2. Leakage class as scheduled, minimum Class 2, rated per UL 555S
3. Locate damper in sleeve starting at approximately 3” from end of the sleeve opposite the damper actuator end. (Damper shall be installed with this end protruding 3 inches out from inside surface of wall.)
4. Horizontal dampers shown on Drawings to be supported by a drywall rated enclosure (rather than a framed concrete opening) shall be listed for this application.

D. Actuator
   1. UL 555S listed
      a. 120 volt two position unless otherwise indicated on drawings
   2. Spring return normally closed unless otherwise indicated on drawings
   3. Electronic cut-out at full-open so that actuator creates no noise holding open
   4. Permanently lubricated gears
   5. Direct coupled with cold-weld steel clamp; aluminum clamp and external linkage not acceptable
   6. For multiple damper sections using one actuator, jackshafts between sections shall be welded, not bolted or screwed.

E. Controls
   1. Heat-actuated electric release
      a. Controlled closure to prevent duct and HVAC component damage
      b. Damper to automatically reopen after a test, smoke detection or power failure condition. In the event of heat activated closure, the damper must be manually reset at the damper.
      c. Release temperature: as scheduled on drawings.
      d. Ruskin EFL or equal
   2. Status end switches
      a. Only where scheduled on Drawings
      a. Built into the direct-coupled actuator; blade mounted end switch packages are not acceptable.
      b. For dampers with multiple actuators, status switches are required for each independent damper section; sections that have multiple actuators and that also have jackshafts connecting the dampers in each section together shall have actuator end switches on only one actuator.
      c. UL 555S listed
      d. California State Fire Marshal approved

F. Type: as indicated on the Drawings

2.6 SOUND ATTENUATORS

A. Factory prefabricated

B. Shell
   1. Galvanized steel: minimum 22 gage
   2. Leakproof at pressure differential of 8 inches water gage

C. Media:
   1. Flamespread: maximum 25
   2. Fuel contributed and smoke developed: maximum 50
   3. Minimum 4.5 pounds per cubic foot density glass or mineral fiber packed under 5 percent compression
   4. Media shall meet erosion test method described in UP Publication No. 181
   5. Filler to be inert, vermin and moisture proof

D. Internal construction: Galvanized perforated steel baffles: minimum 24 gauge

E. Attenuator Performance
   1. See schedule on the Drawings for
      a. Net insertion ratings
      b. Maximum allowable air pressure drop
      c. Model number

F. Certified tests

1. Submit a laboratory certified test data for pressure drop and insertion loss ratings
    a. For square or rectangular attenuators: 24 inch x 24 inch cross-section attenuator
    b. For round attenuators: 24 inch diameter conical attenuator
    c. Certification data for pressure drop and net insertion loss: based on tests of same attenuator
    d. Attenuators and tests: subject to inspection upon request

G. Industrial Acoustics, Inc. Quiet-Duct or equal

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades

B. Install duct accessories in accordance with manufacturer's written installation instructions

C. See Section 233100 Ducts

D. Provide access doors in following locations:
1. Coils in ducts (including at VAV boxes)
    a. Entering and leaving side for cooling coils
    b. Entering side for heating coils
2. Automatic dampers: linkage side
3. Smoke dampers
4. Fire dampers
5. Smoke detection heads enclosed in ducts
6. At the top of each lined duct riser accessible from the fan room floor (for inspection of duct liner)
7. Fan bearings enclosed in ducts
8. Sprinkler heads in ducts
9. Motors, actuators or other accessories that require access or service inside ducts
10. Outdoor air plenums as required to clean plenum from dirt and debris.
11. Where otherwise indicated on the Drawings

E. Volume dampers
1. Provide at locations indicated on the Drawings
    a. Volume dampers shall be installed as far away from air outlets as functionally reasonable to avoid noise in the occupied space.
    b. Provide also in wyes and tap-ins to outlets whether indicated on the Drawings or not, except
        1) Where dampers are not indicated on the Drawings above inaccessible ceilings
        2) To sidewall outlets in exposed ducts (opposed blade dampers in outlets shall be provided where scheduled)
2. Additional locations where dampers appear to be required for balancing, place request for information with Engineer prior to construction.
3. For ductwork exposed to occupant view, volume damper handles shall be on top of duct or otherwise concealed from occupant view.
4. For dampers above non-removable ceilings that are not accessible from ceiling access panels or removable diffusers, provide concealed damper regulator as specified herein or detailed on Drawings.

F. Fire and smoke dampers
1. Provide in ducts and openings as indicated in the Drawings

2. Provide access door in duct adjacent to each in location where damper may be inspected and internal fusible link or fire-stat may be replaced
3. Install duct smoke detector provided by Division 26 if required; see Division 26 drawings
4. Smoke and fire dampers installed in tunnel corridors shall have weight of damper supported from structure above.

G. Control dampers
1. Field mounted control dampers installed with concealed linkage shaft accessible on side of damper with space for direct-coupled actuator
2. Actuator installation: See Division 25 Building Automation Systems

H. Install belt guards at all exposed belts

3.2 MOUNTING AND ALIGNMENT

A. Install all accessories to prevent air leakage.

B. Install closed bearing end on all damper blades that penetrate duct to prevent air leakage.

C. Support extra weight of duct accessories. See Section 230548 Vibration and Seismic Control

3.3 INSPECTION

A. Verify that adequate clearance between duct accessories and adjacent walls or equipment is available to permit maintenance and repairs.

3.4 PRE-OPERATING CHECKS

A. Before operating duct accessories: Set all components in normal operating condition

3.5 TESTING AND ADJUSTING

A. Before operating duct accessories see Section 019100 Commissioning

B. After starting duct accessories
1. Check for noise and leakage; repair as required at no additional cost to the Owner
2. Operation test: Test each piece of equipment to show that it will operate in accordance with requirements.

C. See Section 230593 Testing, Adjusting, and Balancing

D. See Section 230800 Mechanical Commissioning

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 233400

FANS & HOODS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. All fans except where integral with manufactured piece of equipment
   2. Roof type gravity hoods and ventilators

1.2 REFERENCE STANDARDS

A. ANSI/ABMA Standard 9 – Load Rating and Fatigue Life for Ball Bearings

B. AMCA 99 – Standards Handbook

C. AMCA 210 – Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

D. AMCA 300 – Reverberant Room Method for Sound Testing of Fans

E. AMCA 301 – Methods for Calculating Fan Sound

F. ANSI/ABMA 11 – Load Ratings and Fatigue Life for Roller Bearings

1.3 QUALITY ASSURANCE

A. AMCA certified ratings per applicable AMCA standard based on the testing conducted in an independent laboratory

B. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal

C. Sound Ratings: AMCA 301; tested to AMCA 300 and bear the AMCA Certified Sound Rating Seal

D. Fabrication: Conform the AMCA 99

E. Conform to AMCA Bulletins regarding construction and testing
   1. Fans shall bear AMCA certified rating seal

F. Scheduled equipment performance is minimum capacity required.

G. Scheduled electrical capacity shall be considered as maximum available.

H. Scheduled static pressure is external to the fan and does not include the pressure drop of accessories specified to be provided with the fan, such as backdraft dampers, inlet screens, belt tubes, etc. The manufacturer shall include these pressure drops in the fan total pressure such that the scheduled airflow can be achieved at the scheduled external static pressure.

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Fans	R	R		R
Fan & Hood accessories	R	R		

C. Include
   1. Complete graph of fan curves, not just curve for design conditions
   2. Sound power levels
      a. Fans 1 horsepower and larger: dB by octave bands
      b. Fans less than 1 horsepower: sones

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Loren Cook

C. Greenheck

D. Twin City

E. Or equal

2.2 GENERAL

A. Fans shall bear the AMCA certified ratings seal for sound and air performance and be certified in accordance with ARI Standard 210 and 211, and AMCA Standard 2408 for centrifugal fans

B. Fans used shall not increase motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 20 percent, from specified criteria.

C. Performance
   1. See fan schedule on the Drawings
   2. Capacities: minimum as scheduled on the Drawings
   3. Brake horsepower rating: Maximum 10 percent above that scheduled on the Drawings
   4. Fans and drives shall be capable of accommodating static pressure variations of plus or minus 10 percent
   5. Motor horsepower: No larger than that scheduled on the Drawings, or compensate Division 26 contractor for any associated cost to increasing motor size

6. Sound power: No greater than that scheduled on the drawings

D. Wheels
   1. Class as indicated on the Drawings or as required for duty
   2. Formed steel or extruded aluminum
   3. Statically and dynamically balanced in accordance with AMCA Standard 204-96 Balance Quality and Vibration Levels for Fans
   4. Exposed fan wheels protected by finger proof screen where scheduled

E. Shafts
   1. AISI C-1045 hot rolled and accurately turned, ground, and polished
   2. Sized for a critical speed of at least 125% of maximum RPM

F. Motors
   1. Comply with Section 230513 Motors and Controllers.
   2. Provide electrically commutated motor (ECM) where scheduled

G. Housing
   1. Bolted and welded construction utilizing corrosion resistant fasteners
   2. Scroll wrapper and scroll side panels shall be a minimum 12 gauge steel
   3. The entire fan housing shall have continuously welded seams
   4. Spun inlet bell and shaped cut-off for centrifugal fans
   5. Weatherproof drive covers at utility sets shall have access doors

H. Belt Drive
   1. Matched, multiple V-belt
   2. Capacity: minimum 1.5 times motor horsepower
   3. Pulleys
      a. Cast iron
      b. Variable pitch diameter
         1) Except motors with variable speed drives
         2) Fans up to 7-1/2 hp motor
         3) Fans from 10 hp to 25 hp, under 1000 rpm
      c. Fixed pitch diameter
         1) All motors with variable speed drives
         2) Fans 10 hp and over 1000 rpm
      d. Select at mid-point of range
   4. Automatic belt tensioner to maintain proper belt tension and provide quick belt removal and replacement, where scheduled. Equal to Loren Cook.
   5. Companion sheaves to maintain belts parallel
   6. Drive guards
      a. Comply with requirements of State COSHA
      b. Provide holes in belt guards for tachometer readings
      c. Indoor Belt Drives: 16 gage expanded metal or wire screen enclosure with 70 percent free area and steel frame
      d. Outdoor Belt Drives: Provide enclosure over entire motor and drive assembly.

I. Bearings
   1. Designed and tested specifically for use in air handling applications
   2. Heavy duty regreasable ball or roller type in a cast iron pillow block housing
   3. Bearing shaft mounting mechanism shall be concentric mount, not set screw mount.
   4. Grease fittings extended to accessible locations outside housing
   5. Life rating: minimum 200,000 hours per ABMA Standard 9 or 11 L_{50} rating, at maximum catalog speed

J. Painting
   1. Electrostatically applied, baked polyester powder coating, minimum 2 mil thick
   2. Paint must exceed 1,000 hour salt spray under ASTM B117 test method

K. Discharge: As indicated on the Drawings

L. Smoke Exhaust Fans. Fans indicated on drawings as being exhaust fans provided to comply with CBC 909 requirements shall meet all CBC 909 requirements including:
   1. Rated for duty up to 165ºF (or temperature listed in schedule) for 20 minutes
   2. 150% belt safety factor with minimum two belts on belt driven fans

2.3 HOODS AND VENTILATORS

A. Hood
   1. Minimum 18 gauge aluminum
   2. Radius throat
   3. Lifting lugs
   4. Rain gutter
   5. 1/2” galvanized mesh birdscreen

B. Base
   1. Minimum 8 gauge aluminum support structure
   2. Continuously welded curb cap corners
   3. Bolted to hood with corrosion resistant fasteners

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades

B. Install fans in accordance with manufacturer’s written installation instructions.

C. See Section 233100 Ducts for duct connections

D. See Division 25 Building Automation Systems

E. See Section 230800 Mechanical Commissioning

F. Flexible duct connection at inlet and outlet: See Section 230548 Vibration and Seismic Control.

G. Backdraft Dampers
   1. Comply with Title 24 Energy Standards and CMC
   2. Provide backdraft or shutoff dampers for suction or discharge of every exhaust fan as scheduled on the Drawings
   3. See schedules on the Drawings and Section 233300 Duct Accessories for where fan manufacturer may provide dampers and when specialty damper manufacturer must provide them.

H. Roof Mounted Fans and Ventilators
   1. Install on factory fabricated curbs

a. Exception: Install Utility fans as indicated on the Drawings
b. Secured to structure with hold down methods as detailed
c. Made fully weatherproof. See Division 7 Thermal and Moisture Protection for waterproofing and roofing.

3.2 MOUNTING AND ALIGNMENT

A. See Section 230548 Vibration and Seismic Control

3.3 INSPECTION

A. Verify that adequate clearance between fans and adjacent walls or equipment is available to permit maintenance and repairs.

3.4 PRE-OPERATING CHECKS

A. Before operating fans
1. See Section 230800 Mechanical Commissioning.

B. Do not operate fans for any purpose, temporary or permanent, until
1. Ductwork is clean
2. Filters in place
3. Bearings lubricated

3.5 TESTING AND ADJUSTING

A. Before starting fans
1. See Paragraph 3.4B
2. See Section 019100 Commissioning
3. Install belt and motor guards

B. Start and test fans in accordance with manufacturers written installation instructions.

C. Start up and adjust fans to insure proper operation.

D. The submitted sound power level shall be verified through actual measurements and calculations in accordance with AMCA standards 300 and 301.
1. In the event the sound power level data measured or being submitted exceeds the designed level, provide additional sound traps or other sound attenuating devices to supplement the design in order to comply with sound power level specifications. Perform this work, including the additional noise control and any increase in motors Hp and increase in electrical service at no additional cost to the Owner. Submit calculations or measurement results to the Owner's Representative, which substantiate that sound power level produced by the submitted equipment and any required sound attenuating devices do not exceed the specified sound power levels.

E. After starting fans: Check for objectionable noise or vibration. Correct as needed at no additional cost to the Owner.

F. Balancing: See Section 230593 Testing, Adjusting and Balancing

G. Commissioning: See Section 230800 Mechanical Commissioning

3.6 TRAINING

A. See Section 230800 Mechanical Commissioning

END OF SECTION

SECTION 233600

AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following: All air terminal units including
   1. Variable air volume boxes

1.2 REFERENCE STANDARDS

A. ARI Standard 885 – Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminal and Air Outlets

B. UL Standard 1995 − Standard for Safety Heating and Cooling Equipment

C. ASHRAE Standard 130 − Methods of Testing for Rating Ducted Air Terminal Units

1.3 QUALITY ASSURANCE

A. Terminal units rated and certified in accordance with ARI Standard 880-98 Certification Program

B. All electrical components shall be UL listed and installed in accordance with the UL Standard 1995.

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
VAV boxes	R	R		R

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. VAV Boxes
1. Price
2. Titus
3. Envirotech
4. Or equal

2.2 VAV BOXES

A. General
1. Ship as a complete assembly requiring no field assembly (including accessories)
2. Casings
a. Minimum 22-gage, galvanized steel
b. Leakage rating: 10 cubic feet per minute maximum leakage at 1 inch water column, when tested per ASHRAE Standard 130
c. Acoustic lining
1) Material: Fiberglass with high density facing
2) Minimum thickness:
a) Terminals located in conditioned space or return air plenum: 1/2 inch
b) Terminals located in unconditioned spaces: 1 inch
3) Minimum 1.5 pound per cubic foot density
4) Maximum thermal conductivity: 0.28 Btu-in per hour per foot squared per degree Fahrenheit (BTU-inch/h·ft^2·°F) measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75 degrees Fahrenheit
5) Meet erosion test method described in UL publication No. 181
6) Meet smoke developed and flame spread rating requirements of NFPA-90A
7) Meet ASTM C1136 and ASTM C665 for biological growth in insulation
d. Discharge duct connection
3. Controls unit mounted by manufacturer
a. Multi-point, double axis cross-flow, center averaging sensor
1) The minimum amplification factor for even sizes 6 to 16 inch shall be greater than 2.0. Provide documentation with submittal that substantiates compliance with this requirement.
2) Be rated for inlet or discharge duty, as indicated on the Drawings
3) Provide accurate flow sensing regardless of inlet duct configuration
4) Brass balancing taps and unit mounted airflow versus flow sensor pressure signal charts for field airflow measurements
5) Be removable for cleaning when box is used for return or exhaust applications
b. Control panel:
1) For VAV boxes exposed to public view, include control panel with cover to fully enclose VAV box controller
2) Otherwise provide flat mounting bracket for controller
c. For Direct Digital Controls, see Division 25 Building Automation Systems
4. Radiated and discharge sound power
a. Equal or less in each octave band than terminal selections scheduled on the Drawings at noted capacities assuming 1.0 inch inlet static pressure, with a tolerance of + 2 dB in any band.
b. Due to added space and pressure drop, providing additional plenums or attenuators to meet sound power ratings is not acceptable.
5. Total pressure drop
a. Equal or less than terminal selections scheduled on the Drawings at noted capacities, with a tolerance of 0.02 inches of water
b. This limitation is in total, not static, pressure. Where total pressure is not listed on certified performance documents, provide a table of manual adjustments of static pressure with velocity pressure calculated from inlet and outlet velocities.

6. Dampers
    a. Heavy gage steel
    b. Single blade damper; opposed blade dampers are not acceptable
    c. Shaft rotating in self-lubricating Delrin or equal bearings; nylon bearings are not acceptable. Shaft shall be clearly marked on the end to indicate damper position.
    d. Damper shall have durable synthetic seal. Foam seals are not acceptable.
    e. Close-off leakage rating: 5 cubic feet per minute maximum leakage at 1.50 inches water column.
7. Hot water heating coils
    a. Not used

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate work and access with respective trades

B. Install terminal units in accordance with manufacturer's written installation instructions.

C. Duct connections
    1. See Section 233100 Ducts
    2. Provide sheet metal duct connections at VAV box inlet; flexible duct not acceptable
    3. No flexible connection required on duct outlet

D. See Division 25 Building Automation Systems

E. See Section 230800 Mechanical Commissioning

3.2 MOUNTING AND ALIGNMENT

A. Support VAV boxes at four corners with minimum, 1" x 18 gage sheet metal straps or 3/8 inch all-thread rod. Secure lower end of strap to the side of unit casing with minimum two #10 sheet metal screws, or bolt through casing with washers to prevent leakage. Bend end of strap and secure to bottom of casing with one #10 sheet metal screws.

B. See Section 230548 – Vibration and Seismic Control for vibration isolation requirements.

3.3 INSPECTION

A. Verify that adequate clearance between air terminal units and adjacent walls or equipment is available to permit maintenance and repairs.

3.4 TESTING AND ADJUSTING

A. Before operating air terminal units, complete the attached Pre-Functional Test Data Sheet for each air terminal unit. See Section 019100 Commissioning

B. Start and test fans in accordance with manufacturers written installation instructions.

C. Start up and adjust fans to insure proper operation.

D. After starting air terminal units: Check for objectionable noise or vibration. Correct as needed at no additional cost to the Owner.

E. See Section 230593 Testing, Adjusting, and Balancing

F. See Section 230800 Mechanical Commissioning

3.5 TRAINING

A. See Section 230800 Mechanical Commissioning

END OF SECTION

SECTION 233700

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following: All air outlets, inlets, grilles, registers and diffusers except where integral with manufactured piece of equipment

1.2 REFERENCE STANDARDS

A. ARI Standard 650 – Air Outlets and Inlets

B. ASHRAE Standard 70 – Methods of Testing for Rating the Airflow Performance of Outlets and Inlets

C. AMCA Standard 500 – Laboratory Methods of Testing dampers for Rating

D. NFPA Standard 90A – Installation of Air Conditioning and Ventilating Systems

E. NFPA Standard 90B – Standard for the Installation of Warm Air Heating and Air Conditioning Systems

1.3 QUALITY ASSURANCE

A. Comply with ARI Standard 650, ASHRAE Standard 70, AMCA Standard 500, NFPA Standard 90A, and NFPA Standard 90B.

B. Provide outlets and inlets that have, as minimum, throw and noise criteria ratings for each size device as listed in manufacturer's current data, rated as required by the above standards.

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Grilles, registers, and diffusers	R			R
Accessories	R			

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Price

C. Titus

D. Krueger

E. Nailor

F. Or equal

2.2 GENERAL

A. Manufacturer shall examine and approve of application of each outlet.

B. Noise level at design capacities: no larger than diffuser selection indicated on the drawings.

C. Diffuser frame and other options shall be as indicated herein unless otherwise indicated on Drawings.

D. Volume dampers
1. Do not provide dampers built into grille or directly attached to the grille unless specifically called out on Drawings or in this Section.
2. Volume damper key-operated adjustable from face of diffuser on register except as noted
3. Opposed blade

E. Diffuser frame
1. Frame type shall be coordinated with ceiling type. Refer to architectural reflected ceiling Drawings.
   a. At plaster or drywall ceilings, use lay-in diffuser with drywall frame (Price SPF or APF to match diffuser material). Drywall frame to match diffuser color.
2. No visible screw allowed on diffusers or frames, unless otherwise indicated on Drawings or in this Section.
3. Linear and bar diffusers shown as one collinear piece on plans shall be constructed as one piece within manufacturing limitations and to appear as one section if manufacturing limitations require multiple pieces.

F. Outlets may be steel or aluminum unless otherwise indicated on the Drawings.

G. Color
1. Face and frame: Unless otherwise indicated on the Drawings:
   a. General: Factory-baked #26 white enamel
   b. Mounted in exposed unpainted galvanized steel ducts: aluminum
2. Internal parts of grille visible from occupied space, including all visible parts behind the diffuser face such as pattern controllers, back pans of perforated diffusers, and visible parts of plenums: flat black

2.3 STYLES

A. General
   1. See diffuser schedule on the Drawings for outlet style and size
   2. Throw pattern per the Drawings
   3. Specific frame, border, and other product references refer to Price

B. Perforated diffusers and grilles - Steel
   1. Supply: Star-pattern diffuser, Price PDSP
      a. Deflectors factory adjusted for corner blow pattern unless otherwise indicated on Drawings.
   2. Ducted return/exhaust: Price PDDR
   3. Plenum return:
      a. Price PDDR
      b. Light shield

C. Flow Bar
   1. Price AS or JS; slot width as scheduled
   2. Integral plenum. For supply air, include minimum 1/2 inch thick insulation equal to Type AL duct liner as specified under Section 230700 Mechanical Insulation
   3. Border
      a. Drywall ceilings or walls: Equal to Price Border 22
      b. Other: Equal to Price Border 61 with mitered corners, concealed fasteners
   4. Controls
      a. Supply: Adjusta Slot weir gate unless Jet Slot is indicated in schedules
      b. Return or exhaust:
         1) As scheduled, either:
            a) Adjusta Slot with weir gate removed
            b) Jet Slot with blade set vertical for full free area
         2) With light shield

D. Sidewall
   1. Price 500 series as scheduled
   2. Supply air
      a. Double deflection: vertical blades on room side
      b. For grilles or diffusers less than 7 feet above the floor, the maximum centerline blade spacing shall be ½ inch.
   3. Return/exhaust
      a. Parallel fixed blades set at a deflection of 45 degrees or 0 degrees from horizontal as scheduled
   4. Drywall frame with recessed screw holes, face mounting allowed
   5. Register (WSR, WER, etc.) to have opposed blade damper unless otherwise indicated on the Drawings

E. Spiral Duct
   1. Price SDGE
   2. Double deflection, vertical blades on room side
   3. Extruded aluminum with clear anodized finish
   4. No scoops or dampers

F. Thermally powered diffusers
   1. Cooling only:
      a. Acutherm ST-C
      b. Adjustable cooling setpoint via knob/wheel behind diffuser face
   2. Cooling and Heating:
      a. Acutherm ST-HC
      b. Independently adjustable cooling and heating setpoints via knob/wheel behind diffuser face

c. Automatic heating/cooling changeover based on supply air temperature
3. Adjustable minimum flow position stop via knob/wheel behind diffuser face
4. Plaque face

2.4 SCREENED OPENINGS

A. Mesh
1. 3/4 in. square pattern
2. No. 16 galvanized wire
3. Interwoven
4. Welded or secured to frame

B. Frames: Optional
1. 1 inch by 1 inch by 1/8 inch galvanized steel angles
2. Continuous around perimeter of screen

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install air outlets and inlets in accordance with manufacturer's written installation instructions and Section 233100 Ducts.

C. Return and exhaust registers: Install with blades oriented to prevent sight through outlets.

D. Grille backs or plenums visible through grilles painted flat black

E. Transfer grilles
1. See indications on the Drawings
2. Wall installations, unless otherwise indicated, provide two grilles
a. One on each side of wall, except where open to return air plenum
b. Connecting sheet metal collar with 18 inch elevation offset for sound and light attenuation

F. Provide duct screens at termination ducts as indicated on the Drawings

3.2 MOUNTING AND ALIGNMENT

A. See Section 230548 Vibration and Seismic Control

B. All air outlets and inlets shall be secured to building
1. Ceiling grilles shall be secured to prevent falling from ceiling during construction or service with minimum of two 16-gage ceiling wires, two 22-gage by 1 inch galvanized sheet metal strap or two #10 sheet metal screws.
2. Comply with CBC.

C. Mount directional grilles as indicated on the Drawings.

D. Adjust grille throw patterns prior to test and balance. See Section 230593 Testing, Adjusting and Balancing.

3.3 INSPECTION

A. Verify mounting, direction and adjustments are installed as indicated on the Drawings.

3.4 TESTING AND ADJUSTING

A. See Section 019100 Commissioning

B. See Section 230593 Testing, Adjusting and Balancing

C. See Section 230800 Mechanical Commissioning

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 234000

AIR CLEANING DEVICES

PART 1 GENERAL

1.1 WORK INCLUDED

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Filter media

1.2 REFERENCE STANDARDS

A. ASHRAE Standard 52.2 – Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

B. ANSI/UL 900 – Test Performance of Air Filter Units

1.3 QUALITY ASSURANCE

A. Filters shall have MERV and dust loading ratings in accordance with ASHRAE Standard 52.2 with preconditioning as specified in Appendix J of that Standard.

1.4 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Filters	R	R		R
Built up system filter rack and housing	R	R		R
Filter gages	R2	R		

1.5 ***Spare Filter***S

A. Furnish one new complete set of filters (excluding construction filters) for each filter bank on completion and acceptance of the Work.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Filter Media and Frames
   1. Camfil Filtration Group
   2. Flanders/Precisionaire
   3. American Air Filter
   4. Filtration Group
   5. Or equal

2.2 FILTERS

A. General
   1. UL 900 listed
   2. Disposable type
   3. Each filter shall consist of media, media support grid and enclosing frame.
   4. Each filter shall have flow direction and MERV rating permanently affixed to frame.

B. Type 1: Pleated Filter
   1. 2 inch or 4 inch pleat as scheduled
   2. Media: Cotton & synthetic media (no polyester)
   3. Minimum performance:
      a. MERV 8
   4. Maximum initial pressure drop at 500 feet per minute face velocity shall not to exceed 0.3 inches water column. Final pressure drop shall be no less than 1.0 inch water column.
   5. Equal to Camfil 30/30

C. Type 2: Not used

D. Type 3: Bag Filters
   1. Deep pleated replaceable element
   2. Minimum depth: 22 inch
   3. Enclosing frame
      a. Galvanized steel frame and galvanized steel pocket retainers
      b. Header bonded to the media to prevent air bypass
   4. Media
      a. Lofted microfine glass (no polyester)
      b. Chemically bonded to permeable media support backing
   5. Minimum performance
      a. MERV 15
   6. Maximum initial pressure drop at 500 feet per minute face velocity shall not to exceed 0.62 inches water column. Final pressure drop shall be no less than 1.0 inch water column.
   7. Equal to Camfil Hi-Flo ES

2.3 FRAMES

A. For air handlers and fan-coils, see individual specifications Sections.

2.4 FILTER GAUGE

A. See Division 25 Building Automation Systems (DP sensors with LCD display).

PART 3 EXECUTION

3.1 FILTER MEDIA

A. Media as selected in equipment schedules on the Drawings

B. Construction filters
   1. Type 1 for all equipment; roll media not acceptable

3.2 INSTALLATION

A. Factory installed in air handling equipment

B. Coordinate with work of other trades

C. Install Air Cleaning Devices in accordance with manufacturer's written installation instructions.

D. See Division 25 Building Automation Systems

E. See Section 230593 Testing, Adjusting and Balancing

F. See Section 230800 Mechanical Commissioning

3.3 START-UP PROCEDURES

A. Do not operate air handling unit fan systems for any reason until spaces served have been cleaned of dust and debris, to avoid contamination of supply air or return air paths and equipment.

B. Supply fans shall not be operated unless filters are installed, including temporary filters for use during test and balance.

C. If the final pressure drop of the temporary filters is reached during test and balance, replace them with a spare set.

D. Before final air balancing, and immediately before post-construction outdoor air purge if required by Section 230501 Basic Mechanical Materials and Methods remove temporary construction filters and install clean final filters:
   1. Remove prefilters in front of cartridge and bag filters after construction and do not replace. Prefilters shall not be used during for normal operation.
   2. See Section 230593 Testing, Adjusting and Balancing and Section 230501 Basic Mechanical Materials and Methods for media installation during test and balance period.

3.4 INSPECTION

A. Verify that adequate clearance between Air Cleaning Devices and adjacent walls or equipment is available to permit maintenance and replacement of filters.

B. Verify that filters are firmly seated in frame to minimize bypass.

3.5 TRAINING

A. See Section 230800 Mechanical Commissioning

END OF SECTION

SECTION 237300

AIR HANDLING UNITS & COILS

PART 1 GENERAL

1.1 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:
   1. Air handling units

1.2 SUBMITTALS

A. See Section 230501 Basic Mechanical Materials and Methods.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.
   1. "R" means required.
   2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item				
Air handling units	R	R		R

C. Air-Handling Units
   1. List of exceptions to the specifications including section number and a detailed description of alternative materials and methods. If there are no exceptions, so state in precise language.
   2. List of proposed manufactures for fans, filters, coils, motors, drives, dampers and other components
   3. Complete dimensional data including exterior dimensions and dimensions of internal components such as plenum dividers.
   4. Weight
   5. Fans
      a. Complete graph of certified fan curves (not just curve for design conditions) indicating efficiency, BHP, and RPM
      b. Certified fan-sound power ratings
      c. Fan construction and accessories
      d. Motor ratings, electrical characteristics, and motor accessories
   6. Cabinet material, metal thickness, finishes, insulation, and accessories including construction details for panel sealing, thermal break, door seal and hardware, shipping split and field treatment of panel penetration (sleeve) details.
   7. Certified coil-performance ratings with system operating conditions indicated.
   8. Dampers, including housings and linkage
   9. Filters and filter frame product data with performance characteristics
   10. Sound power levels by octave bands; radiated and at inlet and discharge
   11. Wiring diagram
   12. Control panel location, including elevation indicating height above the ground
   13. Internal static pressure drop of all components at design conditions
   14. The number of shipping sections requiring field reassembly and weight and dimensions of each

1.3 QUALITY ASSURANCE

A. Unit shall be completely factory assembled and tested prior to shipment and shall have the approval of one of the following agencies: Underwriters' Laboratories (UL), Electrical Testing Laboratories (ETL) or Canadian Standards Association (CSA). If the manufacturer cannot provide an ETL/UL sticker on the air handler from the factory, it will be the sole responsibility of the manufacturer to arrange for local ETL or UL approval and labeling.

B. Electrical Components, Devices, and Accessories: Built, listed and labeled in strict accordance to the CEC and NFPA 70, and shall bear an appropriate label certifying compliance with UL Standard 508A by a qualified testing agency, and marked for intended location and application.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

D. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

E. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

F. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

G. Water Coils: Factory tested to 350 psig according to ARI 410 and ASHRAE 33.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Nortek Companies

B. Energy Labs

C. Governaire

D. Equal

2.2 ACOUSTICAL PERFORMANCE

A. All sound power level measurements and calculations shall be in complete accordance with the latest version of AMCA Standard 300 Reverberant Room Method for Sound Testing of Fans and AMCA Standard 301 Method for Calculating Fan Sound Ratings from Laboratory Test Data. Test and calculation procedures based on sound intensity measurements may be substituted for the above procedures, if directed in advance by the Owner's Representative.

B. Maximum sound power levels

1. The air handling unit components (e.g. fans, coils, panels) shall be selected and constructed to provide no more than the follow sound power levels under all operating conditions:

		Maximum Sound Power Level, dB						
	Frequency	63	125	250	500	1000	2000	4000
AH-C	Supply air opening							
	Return air opening							
	Radiated							
AH-H	Supply air opening							
	Return air opening							
	Radiated							

2.3 CONSTRUCTION

A. Cabinet
1. Walls and roof shall be double wall panels
   a. Indoor location: 2 inch thick
2. Outer panel shall be: 16-gauge solid G90 galvanized
3. Inner panel shall be:
   a. Minimum 20-gauge solid 304 stainless steel in the coil and humidifier sections, minimum 1 foot upstream and 3 feet downstream of coil/media.
   b. Minimum 22-gauge G90 perforated bright galvanized steel liner in all other sections
4. Construction shall comply with one of the following options:
   a. Option 1: All exterior panel seams shall be stitch welded and continuously sealed with a urethane sealant.
   b. Option 2: Exterior panels shall be mechanically connected with thermal break and sealed with an industrial EPDM gasket to form a water and airtight seal. Gasket seal shall not be exposed to UV light or the weather. Fasteners used to attach the panels shall be stainless steel, bolt-type construction that can be removed and refastened and shall not penetrate the air tunnel. Sheet metal screws are not acceptable.
   c. Option 3: Panels shall be of standing seam construction with seams turned inward to provide a smooth flush exterior. Panels shall be screwed together on maximum 8" centers with minimum 5/16" zinc plated screws sealed with a continuous bead of silicone caulking applied between the matching panel seams prior to assembly, and with a final bead following assembly on both the exterior and interior panel seams to produce an air tight unit. Wall to base skin and wall to roof panel seams shall be sealed with 1/2" x 1/8" Poron-Rubber strips and all exterior seams shall be continuously caulked to assure leak-proof integrity of the unit housing.
5. Insulation:
   a. Wall and roof panels shall be insulated with 3 pound density pre-molded rigid board fire-resistant with scrim-Kraft - PSK faced insulation or polyisocyanurate foam.
   b. All panels shall feature a Class A thermal break.
   c. Thickness to match panel wall thickness specified herein with the following minimum R-values including the impact of thermal short-circuits:
      1) 2 inch panel: R-8
   d. Insulation to meet NFPA 90A, NFPA 90B and ASTM E 84 requirements for Flame Spread of 25 or less and Smoke Development of 50 or less.
   e. Insulation shall have a thermal conductivity K factor of .23 Btu/hr/Sq. ft/degree F @ 75 F

6. Roof panels
    a. Indoor units: shall be flat with smooth exteriors the same as the side panels.
7. Stiffeners of angle steel shall be supplied as required to maintain a casing deflection criteria of 1/100 at 1.5 times the working pressure.
8. Access Doors
    a. Access doors shall be double wall construction using materials, thickness, and insulation matching those of the associated section. All doors installed downstream of the cooling coil shall include a Class A thermal break. Door-jam & frame shall be constructed of extruded aluminum with continuously welded corners for rigidity. Door panels shall be insulated with expandable foam insulation completely encapsulated and sealed between the door panels and frame. Provide doors located and sized to allow for routine maintenance including motor replacement and filter replacement, electrical components and any other sections or components requiring access or maintenance.
    b. Doors shall be provided with a minimum (2) dual acting heavy duty key locking composite latches through 48" high, (3) latches through 72" high. Latches shall be operable from both the interior and exterior of the unit. Door latches on doors into fan sections shall be provided with a hasp or other mechanism to facilitate locking of the doors. Door hinge shall be heavy duty Stainless Steel.
    c. Doors shall be provided with double high performance closed cell replaceable neoprene bulb type gasket seals around the entire perimeter of the door / frame.
    d. Doors shall open against static pressure unless obstructed by internal components. If obstructed by internal components on the positive sections requiring access, the doors shall open with pressure and shall be provided with a safety restraining mechanism. Doors used to access rotating equipment shall be provided with an OSHA approved safety latching mechanism requiring a tool to open and shall also have a highly visible, permanently fixed, caution sign on the exterior of the door. Doors with access to moving parts must also have locking hardware and meet current UL mechanical protection guidelines. Standard door size shall be 24" wide by 60" high unless restricted by height or section width.
    e. Viewing Window
        1) Located in access doors to these sections plus those shown in other sections on drawings:
            a) Supply Fan
            b) Return/relief Fan
        2) Thermal pane wire glass
        3) Minimum window size shall be 8 inches by 12 inches.

B. Internal walls and plenum dividers
1. Walls separating return air/access vestibule from coil sections, supply discharge plenum, and mixed air plenum shall be 2 inch double wall panel constructed and insulated as specified for 2 inch exterior panels except with both panels as specified for inside panel. Return air/access side of all plenum walls shall be perforated.
2. Other plenum walls and blank-off plates shall be single wall, fabricated of formed 16 gage solid galvanized steel panels except cooling coil blank-off plates which shall be constructed of 16 gage solid stainless steel.
3. Provide access panels in wall sections where components cannot be easily accessed or removed through the exterior access doors.

C. Bases
1. Unit bases shall be constructed from structural steel channel iron around the entire perimeter of the unit and provided with intermediate structural tubing, channel and angle iron as required to support all internal components. All tubing, channel and angle joints shall be solid welded. Bolted or formed channel bases are not acceptable.
2. Floor Construction
    a. The entire section base (component sections and service vestibule) shall have a floor of continuously welded minimum 12 gauge G90 galvanized steel or aluminum tread plate.

b. Include a minimum 2 inch upturned lip around the section perimeter and all floor openings. No lips or flanges allowed in walking areas to prevent a trip hazard.
c. Floor shall be capable of supporting a 300 lb. live load with maximum L/200 deflection at any floor seam.
d. Fastener penetrations thru the floor sheets not acceptable.
e. Base shall be insulated with water impervious foam under the base skin and covered with a minimum 20 gauge galvanized steel liner. Insulation R-value (including effect of thermal short circuits) shall meet same criteria as cabinet casing requirements specified herein.
f. All floor openings greater than 8 inches in either dimension, including dampers openings, shall be covered with a removable galvanized steel or aluminum grating bolted in place suitable for walking on which will prevent any personnel and large objects from falling through into the space below. Grating shall be capable of supporting minimum 100 pounds/ft^2.

3. Drain pans
a. Under cooling coil and humidifier sections and extending under blank plenum section downstream and extending under all headers and return bends. To aid in coil cleaning, drain pans shall be installed under all coils, including all heating coils.
b. Type 304 Stainless steel, minimum 16-gage
c. Corners soldered, welded or brazed
d. Pitched to drain flange to fully drain. Double broken, double sloped to ensure no standing water.
e. Fully accessible for cleaning
f. Drain connection
1) Minimum size per code
2) Extended to the exterior of the air handler
3) Stainless steel or brass
4) Welded or soldered into bottom of pan
5) Intermediate pans shall drain to the bottom main pan
g. Insulation on bottom drain pan: minimum 1 in. thick, coated fiber glass board or injected foam insulation, NFPA-90 or UL listed. (Intermediate drain pans need not be insulated.)

2.4 FAN ARRAY

A. The fan array shall include multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, minimum Class II or class III as required. Fans shall be rated in accordance with and certified by AMCA for performance.

B. Each fan/motor cell shall include a 12-gauge, G90 Galvanized steel intake wall, 14 gauge spun steel fan inlet funnel, and a 10-gauge G90 Galvanized steel motor support plate rail and structure. Inlet plate, inlet cone and motor base support shall be powder coated. Fan cell structure shall be heavy gauge, anodized aluminum, interior perforated panels and exterior panels shall be aluminum.

C. The fan array shall consist of multiple fan and motor cells, spaced in the airway tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. In order to assure uniform velocity profile in the AHU cross section, the fan cell dimensions must be variable, such that each fan rests in an identically sized cell, and in a spacing that must be such that the submitted array dimensions fill a minimum of 90% of the cross sectional area of the AHU air way tunnel. There shall be no blank off plates or “spacers” between adjacent fan columns or rows to position the fans across the air way tunnel. The array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit to equal the specified cooling coil and/or filter bank face velocity by ±10% when measured at a point 36 inches from the intake side of the fan array intake plenum wall, and at a distance of 72 inches from the discharge side of the fan array intake

plenum wall. Submittals for units providing less than the scheduled quantity of fans and/or spacing of the fans for multiple fan arrays shall submit CFD modeling of the air flow profile for pre-bid approval that indicates uniform velocity and flow across all internal components without increasing the length of the AHU unit or changing the aspect ratio of the unit casing as designed.

D. Fan housing shall include sound absorbing acoustic baffles as required to meet specified sound power levels.

E. Back flow prevention. Each individual cell in the multiple fan arrays shall be provided with an integral backflow prevention device that prohibits recirculation of air in the event a fan or multiple fans become disabled. The system effects for the backflow prevention device(s) shall be included in the criteria for TSP determination for fan selection purposes, and shall be indicated as a separate line item SP loss in the submittals. Back-flow device blades and frame shall be constructed of aluminum.

F. Vibration Control
   1. Option 1. Each individual fan assembly shall be free-floating at all four corners on minimum 2" deflection spring type isolators with seismic restraints. The spring isolators shall be mounted to structural steel members and shall be rated for a minimum of 1G. The fan discharge shall be isolated from the cabinet by means of a neoprene-coated flexible connection.
   2. Option 2. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-5, to meet or exceed an equivalent Grade G.55, producing a maximum rotational imbalance of 0.022" per second peak, filter in (0.55mm per second peak, filter in). All fan and motor assemblies with 27" dia. and less shall be balanced to meet or exceed the G.55 residual unbalance. Fan and motor assemblies submitted for approval incorporating larger than 10 HP motors shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of 0.022" per second peak filter in (0.55 mm per second peak, filter in).

G. Each fan & motor assembly shall be removable through the access door located on the discharge side of the fan wall array.

H. Filter Rating
   1. Where the unit has both prefilters and final filters, select fan using clean filter pressure drops for both the pre-filters and final filters.
   2. Where the unit has only final filters, select fan for mean air pressure drop (midway from clean to maximum).

2.5 HOT AND CHILLED WATER COILS

A. Extended surface type coils
   1. Copper Tubes
      a. Brazed or welded joints
      b. Minimum thickness: 0.020 inches
      c. Outside diameter: 1/2 inch or 5/8 inch
      d. The use of internal restrictive devices such as turbolater springs or ribbons to obtain turbulent construction is not acceptable.
   2. Plate fins
      a. Aluminum
      b. Minimum thickness 0.0075 inches

B. Rows and fin spacing
   1. To meet performance scheduled at similar pressure drop; no fewer rows than that scheduled

2. Selected with tube fouling factor of 0.0001
3. Maximum fin spacing: Meet Standard 62.1 maximum pressure drop requirement (≤0.75 in.w.c. at 500 fpm, dry coil)
4. Select to avoid moisture carryover

C. Circuiting: full row, single circuit, fully overall counterflow

D. Headers
1. Cleanable/removable: cast iron with steel piping connections
2. Steam: cast iron or steel header with steel piping connections
3. All other: Copper with red brass piping connections

E. Certified by AHRI per current Standard 410

F. For field installed coils, coil frame designed for bolting to other sections or ductwork:

G. Coil Casing
1. Minimum 16-gage
2. Fan-coils: galvanized steel casing and tube sheet
3. Air handling units: Type 304 stainless steel casing and tube sheet
4. Intermediate supports of same material as casing

H. Design for 200 pounds per square inch, 250 degrees Fahrenheit unless otherwise indicated on the Drawings

I. Factory tested to
1. 300 pounds per square inch for water coils
2. 450 pounds per square inch for refrigeration condenser coils
3. 300 pounds per square inch for refrigeration evaporator coils

J. Factory cleaned, degreased, and flushed. Piping connections shall be capped with removable caps.

K. Stacked coils shall be mounted in racks to allow individual coil removal without interference to other coils. Racks shall be designed to allow coil removal through the roof of the unit if required. All coils shall be removable from either side of the unit by easily removable end panels. Individual end panels shall be supplied for each coil on the supply and return side of the cabinet to allow single coil piping breakdown for coil removal.

L. Coil supply and return piping connections extending through the cabinet wall shall be sealed by rubber grommets with caulking on the exterior of the casing. The escutcheon plate shall have a rolled collar around the pipe opening to protect the pipe and be equipped with an “O” ring rubber gasket between the collar and the pipe to prevent chaffing and provide an air tight seal around the opening.

2.6 FILTERS

A. Filters shall be arranged for Face, Rear or side loading as indicated on the detail drawings. Face loading is preferred where space allows. Face or rear loading shall be in gasketed universal holding frames. The filter rack assemblies shall be blanked off to the sides, roof and floor and properly sealed to minimize filter bypass

B. Filter Gauge – see Section 250000 BAS.

C. Filter banks shall be sized so maximum filter face velocity does not exceed 500 fpm unless otherwise shown on drawings.

D. Filter type
   1. As scheduled
   2. In accordance with Section 234000 Air Cleaning Devices.

2.7 ELECTRICAL

A. Provide separate panels, each with an externally operated non-fused main disconnect switch, for separate field power connections for the following:
   1. Supply fan motors
   2. Lighting

B. Each air handling unit shall contain electrical control panels consisting of a surface mounted or fully recessed NEMA rated enclosure.

C. All motors in the fan array shall be provided with individual disconnects and thermal overload protection. All motor circuit protectors shall be located in main enclosure. Include the following for AHUs used for life safety smoke control: Disconnects shall have auxiliary contacts for monitoring position status by the Fire Alarm System.

D. Motors
   1. Comply with Section 230513 Motors and Controllers.
   2. Motors shall be standard foot mounted type, TEFC or TEAO, premium efficiency.
   3. Motors, and shall be “off-the-shelf”, available from local motor suppliers, either 1800 or 3600 nominal RPM.
   4. Motors shall include permanently sealed bearings
   5. The weight of any individual motor shall not exceed 200-lbs.
   6. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2. (invertor-duty).
   7. Where recommended by VFD manufacturer, include shaft grounding system equal to AEGIS SGR unless motor has ceramic bearings
   8. Each motor shall be provided with individual disconnects and thermal overload protection, located in main electrical enclosure.

E. Variable speed drives
   1. VSDs are field installed and provided by others.

F. Lights
   1. Provide vapor proof marine type mini-fluorescent light fixtures in each accessible section complete with a protective metal cage and sealed glass enclosure. Cabinets greater than 14 feet in width shall have two fixtures per section.
   2. Lights shall be wired to a common switch mounted in a weatherproof box adjacent to the fan access door complete with a GFCI convenience outlet and indicator light.
   3. All wiring to lights shall be in conduit and internal to the unit. No external conduit runs for the lights are allowed.
   4. If the unit requires splitting, junction boxes shall be furnished at each section to allow the electrical contractor to make final connections in the field. Wiring shall be clearly labeled at junction points to facilitate reconnection.

G. Controls
   1. All controls provided under Division 25 Building Automation Systems.

2.8 DAMPERS

A. Dampers shall comply with 233300 Duct Accessories. Construction and performance shall match that of Ruskin models specified below.

B. Type and Size
   1. Return air
      a. Listed smoke damper due to atrium makeup duty
      b. Equal to Ruskin SD-60
      c. Parallel blade
      d. System with relief fans: 1000 fpm sized for supply fan design airflow less design minimum outdoor airflow
      e. System with return fans: 1500 fpm sized for supply fan design airflow less design minimum outdoor airflow
   2. Economizer Outdoor air
      a. Equal to Ruskin CD-50
      b. Parallel blade
      c. 400 to 1000 fpm sized for supply fan design airflow

C. Actuators are specified under Section 250000 BAS.

D. Damper configuration
   1. Each section shall be designed to be operated by a separate direct coupled actuator. Jackshafts and external linkage shall not be used. Provide space between damper sections (or between damper and roof/floor for vertical blade dampers) to allow for side-mounted direct-coupled actuator.
   2. Do not interlink economizer outdoor air and return air dampers. Each shall operate independently.
   3. Economizer outdoor air and return airflow shall be directed into each other. Provide vertical blades if required.

1.1 AIR OPENINGS

A. Size
   1. Supply Air: ≤ 1500 fpm face area
   2. Return Air: ≤ 1000 fpm face area

B. Protection
   1. For floor openings, provide minimum 80% free area walking grate where opening is in an accessible section.
   2. For all other openings, cover opening with a heavy-duty screen.

2.9 UNIT TESTING AND QUALITY CONTROL

A. Equipment Qualification
   1. Prior to unit shipment, the following qualifications shall be performed and documented:
      a. All fans shall be balanced and factory run tested to ensure design integrity.
      b. All bearings shall be provided with a full complement of grease.
      c. All factory piping shall be leak tested to ensure integrity.
      d. All electrical circuits shall be tested to ensure correct operation.
      e. Drain pans shall be tested to ensure positive slope to drain. (See also post-installation tests performed under Section 230593 Testing, Adjusting and Balancing.)

PART 3 EXECUTION

3.1 INSTALLATION

A. Units shall ship with all openings securely covered and watertight. Protection shall be retained until completion of construction or until opening is field connected to ductwork.

B. Coordinate with work of other trades.

C. Vibration isolation and mounting: See Section 230548 Vibration and Seismic Control.

D. Install in accordance with manufacturer's written installation instructions.

E. Mount units sufficiently high to allow for proper condensate trapping and drainage.

F. Piping
   1. See Section 232113 HVAC Piping
   2. See piping diagrams
   3. Do not block access doors with piping. Access doors shall be capable of opening 90 degrees.
   4. Pipe condensate to nearest appropriate drain. See Division 220000 Plumbing.

G. See Division 25 Building Automation Systems

3.2 INSPECTION

A. Verify that adequate clearance between air handling units and adjacent walls or equipment is available to permit maintenance and repairs.

3.3 PRE-OPERATING CHECKS

A. Before operating air handling units:
   1. See Section 230800 HVAC Commissioning.
   2. Complete Pre-Functional Test Data Sheet for each unit.

3.4 CLEANING

A. After completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean all components including fan wheels, cabinets, dampers, coils, and filter housings.

B. Install new, clean filters in accordance with Section 234000 Air Cleaning Devices.

3.5 TESTING AND ADJUSTING

A. Do not operate fans for any purpose, temporary or permanent until
   1. Ductwork is clean
   2. Filters are in place
   3. Bearings are lubricated

4. Fan has been run under observation

B. Start and test fans in accordance with manufacturer's written installation instructions.

C. Test cooling coil drain pans. See Section 233300 Duct Accessories

D. Start-up and adjust completed air handling units to ensure proper operation

E. See Section 230593 Testing, Adjusting, and Balancing

F. After starting fans: Check for objectionable noise or vibration. Correct as needed at no additional cost to the Owner.

G. Commissioning: See Section 230800 Mechanical Commissioning.

H. Training: See Section 230800 Mechanical Commissioning.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 250000

BUILDING AUTOMATION SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Furnish and install a digital Building Automation System (BAS) as specified herein.

B. Coordination with other Divisions: See coordination matrix in Section 230501 Basic Mechanical Materials and Methods.

1.2 CONTRACTOR PROPOSALS

A. The system requirements described in this specification are generally performance based. Where requirements are prescriptive, the intent is to provide minimum quality, not to give unfair advantage to any given manufacturer or product. If a contractor finds that a certain requirement is unduly difficult or expensive to meet, contact the Engineer prior to bid due date and an addendum modifying the requirement will be considered.

B. Where requirements are unclear, the contractor shall clarify the requirements with the Engineer before the bid due date. Where requirements continue to be unclear, the contractor's proposal must accurately describe what is included and excluded.

C. By submitting a proposal, contractor guarantees that their proposal is in full compliance with these specifications except as specifically excluded in their proposal.

1.3 REFERENCE STANDARDS

A. Nothing in Contract Documents shall be construed to permit Work not conforming to applicable laws, ordinances, rules, and regulations. When Contract Documents differ from requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.

B. The latest published or effective editions, including approved addenda or amendments, of the following codes and standard shall apply to the BAS design and installation as applicable.

C. State, Local, and City Codes
1. CBC − California Building Code
2. CMC − California Mechanical Code
3. CEC – California Electrical Code
4. Local City and County Codes

D. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
1. ANSI/ASHRAE 135 – BACnet - A Data Communication Protocol for Building Automation and Control Networks.
2. ANSI/ASHRAE Standard 15 – Safety Standard for Refrigeration Systems.

E. Electronics Industries Alliance
   1. EIA-232 – Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
   2. EIA-458 – Standard Optical Fiber Material Classes and Preferred Sizes.
   3. EIA-485 – Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
   4. EIA-472 – General and Sectional Specifications for Fiber Optic Cable.
   5. EIA-475 – Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
   6. EIA-573 – Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
   7. EIA-590 – Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.

F. Underwriters Laboratories
   1. UL 916 – Energy Management Systems.

G. National Electrical Manufacturers Association
   1. NEMA 250 – Enclosure for Electrical Equipment.

H. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 142 – Recommended Practice for Grounding of Industrial and Commercial Power Systems.
   2. IEEE 802.3 – CSMA/CD (Ethernet – Based) LAN.
   3. IEEE 802.4 – Token Bus Working Group (ARCNET – Based) LAN.

1.4 DEFINITIONS

A. Acronyms

AAC	Advanced Application Controller
AH	Air Handler
AHU	Air Handling Unit
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
ASC	Application Specific Controllers
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
A-to-D	Analog-to-Digital
BACnet	Data Communications Protocol for Building Automation and Control Systems
BC	Building Controller
BIBB	BACnet Interoperability Building Blocks
BTL	BACnet Testing Laboratory
CAD	Computer Aided Drafting
CHW	Chilled Water
CHWR	Chilled Water Return

CHWS	Chilled Water Supply
COV	Change of Value
CSS	Control Systems Server
CU	Controller or Control Unit
CV	Constant Volume
CW	Condenser Water
CWR	Condenser Water Return
CWS	Condenser Water Supply
DBMS	Database Management System
DDC	Direct Digital Control
DHW	Domestic Hot Water
DI	Digital Input
DO	Digital Output
D-to-A	Digital-to-Analog
BAS	Building Automation System
EMT	Electrical Metallic Tubing
EP	Electro-Pneumatic
ETL	Edison Testing Laboratories
GUI	Graphical User Interface
HHD	Hand Held Device
HOA	Hand-Off-Automatic
HVAC	Heating, Ventilating and Air-Conditioning
HTTP	Hyper-Text Transfer Protocol
I/O	Input/output
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
LAN	Local Area Network
LANID	LAN Interface Device
MAC	Medium Access Control
MHz	Megahertz
MS/TP	Master-Slave/Token-Passing
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
ODBC	Open Database Connectivity
OI	Operator Interface
OWS	Operator Workstation
P	Proportional
PC	Personal Computer
PI	Proportional-Integral
PICS	Protocol Implementation Conformance Statement
PID	Proportional-Integral-Derivative
POT	Portable Operators Terminal
PTP	Point-to-Point
RAM	Random Access Memory
SOO	Sequence of Operation
SQL	Standardized Query Language
SSL	Secure Socket Layers
TAB	Test, Adjust, and Balance

TDR	Time Delay Relay
UFT	Underfloor Fan Terminal Box
UL	Underwriters' Laboratories, Inc.
XML	Extensible Markup Language

B. Terms

Term	Definition
Accessible	Locations that can be reached with no more than a ladder to assist access and without having to remove permanent partitions or materials. Examples include inside mechanical rooms, mechanical equipment enclosures, instrument panels, and above suspended ceilings with removable tiles.
BACnet Interoperability Building Blocks	A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device in a specification.
BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
Change of Value	An event that occurs when a digital point changes value or an analog value changes by a predefined amount.
Client	A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.
Concealed	Embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.
Continuous Monitoring	A sampling and recording of a variable based on time or change of state (such as trending an analog value, monitoring a binary change of state).
Contract Documents	Specifications, drawings, and other materials provided with request for bids.
Control Systems Server	A computer(s) that maintain(s) the systems configuration and programming database.
Controller	Intelligent stand-alone control device. Controller is a generic reference to BCs, AACs, and ASCs.
Direct Digital Control	Microprocessor-based control including Analog/Digital conversion and program logic.
Building Automation System	The entire integrated management and control system.
Equal	Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.
Exposed	Not installed underground or concealed.
Furnish	To purchase, procure, acquire and deliver complete with related accessories.
Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.

Term	Definition
Hand Held Device	Manufacturer's microprocessor based portable device for direct connection to a field Controller.
Inaccessible	Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.
Indicated, shown or noted	As indicated, shown or noted on drawings or specifications.
Install	To erect, mount and connect complete with related accessories.
Instrumentation	Gauges, thermometers and other devices mounted in ductwork or piping that are not a part of the BAS.
IT LAN	Reference to the facility's Information Technology network, used for normal business-related e-mail and Internet communication.
LAN Interface Device	Device or function used to facilitate communication and sharing of data throughout the BAS.
Local Area Network	Computer or control system communications network limited to local building or campus.
Master-Slave/Token Passing	Data link protocol as defined by the BACnet standard.
Motor Controllers	Starters, variable speed drives, and other devices controlling the operation of motors.
Native BACnet Device	A device that uses BACnet for communication. A device may also provide gateway functionality and still be described as a Native BACnet device.
Native BACnet System	A network composed only of Native BACnet Devices without gateways.
Open Database Connectivity	An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.
Open Connectivity	OPC is an interoperability standard developed for industrial applications. OPC compliant systems make it possible to access or exchange data from any application, regardless of which database management system is handling the data.
Operator Interface	A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.
Operator Workstation	The user's interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.
Owner	The Owner or their designated representatives.
Piping	Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.

Term	Definition
Points	All physical I/O points, virtual points, and all application program parameters.
Point-to-Point	Serial communication as defined in the BACnet standard.
Portable Operators Terminal	Laptop PC used both for direct connection to a controller and for remote dial up connection.
Primary Controlling LAN	High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs.
Protocol Implementation Conformance Statement	A written document that identifies the particular options specified by BACnet that are implemented in a device.
Provide	Furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.
Reviewed, approved, or directed	Reviewed, approved, or directed by or to Owner's Representative.
Router	A device that connects two or more networks at the network layer.
Secondary Controlling LAN	LAN connecting AACs and ASCs.
Server	A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
Standardized Query Language	SQL - A standardized means for requesting information from a database.
Supervisory LAN	Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs, CSS, and THS. See System Architecture below.
Supply	Purchase, procure, acquire and deliver complete with related accessories.
Wiring	Raceway, fittings, wire, boxes and related items.
Work	Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

1.5 QUALITY ASSURANCE

A. Materials and Equipment
   1. Manufacturer's Qualifications: See 2.1 for approved manufacturers.

B. Installer
   1. BAS Contractor's Project Manager Qualifications: Individual shall specialize in and be experienced with direct digital control system installation for not less than 3 years. Project Manager shall have experience with the installation of the proposed direct digital control equipment product line for not less than 2 projects of similar size and complexity. Project Manager must have proof of having successfully completed the most advanced training offered by the manufacturer of the proposed product line.

2. BAS Contractor's Programmer Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system programming for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Programmers must show proof of having successfully completed the most advanced programming training offered by the vendor of the programming application on the proposed product line.
3. BAS Contractor's Lead Installation Technician Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system installation for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Installers must show proof of having successfully completed the installation certification training offered by the vendor of the proposed product line.
4. BAS Contractor's Service Qualifications: The installer must be experienced in control system operation, maintenance and service. BAS Contractor must document a minimum 5-year history of servicing installations of similar size and complexity. Installer must also document at least a 1-year history of servicing the proposed product line.
5. Installer's Response Time and Proximity
    a. Installer must maintain a fully capable service facility within 50 miles of the subject Project. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
    b. Installer must demonstrate the ability to meet the emergency response times listed in Paragraph 1.11B.1.
6. Electrical installation shall be by manufacturer-trained electricians
    a. Exception: Roughing in wiring and conduit and mounting panels may be subcontracted to any licensed electrician.

1.6 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner's Representative.

B. Submit drawings and product data as hereinafter specified. Conditions in this Section take precedence over conditions in Division 1 or Section 230501 Basic Mechanical Materials and Methods.

C. Submittal Schedule: Submittal schedule shall be as follows unless otherwise directed by the Owner's Representative:
1. Allow 10 working days for approval, unless Owner's Representative agrees to accelerated schedule.
2. Submittal Package 0 (Qualifications) shall be submitted with bid.
3. Submittal Package 1 (Hardware and Shop Drawings) shall be submitted in accordance with schedule established by the Owner in bid documents.
4. Submittal Package 2 (Programming and Graphics) and shall be submitted no less than 30 days before software is to be installed in field devices.
5. Submittal Package 3 (Pre-Functional Test Forms) shall be submitted no less than 30 days prior to conducting tests.
6. Submittal Package 4 (Pre-Functional Test Report) shall be submitted no less than 14 after conducting tests.
7. Submittal Package 5 (Post-Construction Trend Points List) shall be submitted 14 days prior to the start of the trend collection period.
8. Submittal Package 6 (Functional Test Report) shall be submitted no more than 7 days after conducting tests.

9. Submittal Package 7 (Training Materials) shall be submitted no less than 14 days prior to conducting first training class.
10. Submittal Package 8 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation.
11. Submittal Package 9 (End-of-Warranty Trend Logs) shall be submitted 30 days prior to the end of the warranty period.

D. Submission and Resubmission Procedure
1. Optional Pre-Submittals. At Contractor's option, electronic submittals indicated below may be submitted unofficially via email directly to the Engineer for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time.
2. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as SUBMITTAL 250000-01.
3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 250000-01 REVISION 1.
4. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.
5. Submittals shall have bookmarks for each subsection (e.g. Materials, Drawings) and each for each drawing including drawing number and name.
6. Owner's Representative will return a memo or mark-up of submittal with comments and corrections noted where required.
7. Make corrections
    a. Revise initial submittal to resolve review comments and corrections.
    b. Indicate any changes that have been made other than those requested.
    c. Clearly identify resubmittal by original submittal number and revision number.
8. Resubmit revised submittals until no exceptions are taken.
9. Once submittals are accepted with no exceptions taken, provide
    a. Complete submittal of all accepted drawings and products in a single electronic file.
    b. Photocopies or electronic copies for coordination with other trades, if and as required by the General Contractor or Owner's Representative.

E. Submittals Packages
1. Submittal Package 0 (Qualifications)
    a. Provide Installer and Key personnel qualifications as specified in Paragraph 1.5B.
    b. Format: Word-searchable format per Paragraph 1.7C.3.
2. Submittal Package 1 (Hardware and Shop Drawings)
    a. Hardware
        1) Organize by specification section and device tags as tagged in these specifications.
        2) Do not submit products that are not used even if included in specifications.
        3) Include a summary table of contents listing for every submitted device:
            a) Tab of submittal file/binder where submittal is located
            b) Device tag as tagged in these specifications (such as TS-1A, FM-1)
            c) Specification section number (down to the lowest applicable heading number)
            d) Whether device is per specifications and a listed product or a substitution
            e) Manufacturer
            f) Model number
            g) Device accuracy (where applicable)
            h) Accuracy as installed including wiring and A/D conversion effects (where applicable)

4) Submittal shall include manufacturer's description and technical data, such as performance data and accuracy, product specification sheets, and installation instructions for all control devices and software.
5) When manufacturer's cut-sheets apply to a product series rather than a specific product, the data specifically applicable to the Project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.
6) Format: Word-searchable format per Paragraph 1.7C.3.

b. Shop Drawings
1) System architecture one-line diagram indicating schematic location of all control units, workstations, LAN interface devices, gateways, etc. Indicate address and type for each control unit. Indicate media, protocol, baud rate, and type of each LAN.
2) Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. The schematics provided on Drawings shall be the basis of the schematics with respect to layout and location of control points.
3) All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
4) Label each input and output with the appropriate range.
5) Device table (Bill of Materials). With each schematic, provide a table of all materials and equipment including:
   a) Device tag as indicated in the schematic and actual field labeling (use tag as indicated in these specifications where applicable and practical)
   b) Device tag as indicated in these specifications where applicable and if it differs from schematic device tag
   c) Description
   d) Proposed manufacturer and model number
   e) Range
   f) Quantity
6) With each schematic or on separate valve sheet, provide valve and actuator information including pipe size, valve size, C_v, design flow, target pressure drop, actual design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of fail-safe valves and dampers.
7) Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
8) Details of control panels, including controllers, instruments, and labeling shown in plan or elevation indicating the installed locations.
9) Floor plans: None required.
10) Format
   a) Sheets shall be consecutively numbered.
   b) Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
   c) Table of Contents listing sheet titles and sheet numbers.
   d) Legend and list of abbreviations.
   e) Schematics
      1. Word searchable pdf format.

2. 21 inch x 15 inch or 17 inch x 11 inch.
f) Floor plans: None required

c. Do not include sequence of controls on shop drawings or equipment submittals; they are included in Submittal Package 2.

3. Submittal Package 2 (Programming and Graphics)
   a. A detailed description of point naming convention conforming to Paragraph 3.12B to be used for all software and hardware points, integrated with existing database convention.
   b. A list of all hardware and software points identifying their full text names, device addresses and descriptions.
   c. Control Logic Documentation
      1) Submit control logic program listings (graphical programming) consistent with specified English-language Sequences of Operation for all control units.
      2) Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.
      3) Include specified English-language Sequences of Operation of each control sequence updated to reflect any suggested changes made by the Contractor to clarify or improve the sequences. Changes shall be clearly marked. SOO shall be fully consistent with the graphical programming. (An electronic version of the sequences of controls in Paragraph 3.12 will be provided to the Contractor upon request.)
      4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.
      5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.
   d. Graphic screens of all required graphics, provided in final colors.
   e. Format
      1) Points list: Word-searchable format per Paragraph 1.7C.3.
      2) Programming: Native ALC Eikon or EC-gfxProgram.
      3) Programming and operating manual: Word-searchable format per Paragraph 1.7C.3.
      4) Graphics: Graphical electronic format (pdf, png, etc.).
4. Submittal Package 3 (Pre-Functional Test Forms)
   a. Provide pre-functional test forms as required by Paragraph 3.14D.23.14D.2.a.
   b. Format: Word-searchable format per Paragraph 1.7C.3.
5. Submittal Package 4 (Pre-Functional Test Report)
   a. Provide Pre-Functional Test Report as required by Paragraph 3.14D.2.
   b. Format: Word-searchable format per Paragraph 1.7C.3.
6. Submittal Package 5 (Post-Construction Trend Points List)
   a. Provide a list of points being trended along with trend interval or change-of-value per Paragraph 3.14H.2.d.
   b. Format: See Paragraph 2.11C.3.
7. Submittal Package 6 (Functional Test Report)
   a. Provide completed functional test forms as required by Paragraph 3.14F.4.
   b. Format: Word-searchable format per Paragraph 1.7C.3.
8. Submittal Package 7 (Training Materials)
   a. Provide training materials as required by Paragraph 3.15.
   b. Format: Word-searchable format per Paragraph 1.7C.3.
9. Submittal Package 8 (Post-Construction Trend Logs)
   a. Provide trend logs as required by Paragraph 3.14H.
   b. Format: See Paragraph 2.11C.3.
10. Submittal Package 9 (End-of-Warranty Trend Logs)

a. Provide trend logs as required by Paragraph 3.14H.
b. Format: See Paragraph 2.11C.3.

1.7 COMPLETION REQUIREMENTS

A. Procedure
1. Until the documents required in this Section are submitted and approved, the system will not be considered accepted and final payment to Contractor will not be made.
2. Before requesting acceptance of Work, submit one set of completion documents for review and approval of Owner.
3. After review, furnish quantity of sets indicated below to Owner.

B. Completion Documents
1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format per Paragraph 1.7C.
   a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual.
   b. As-built versions of the submittal product data. Submittal data shall be located in tabs along with associated maintenance information.
   c. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
   d. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.
   e. A list of recommended spare parts with part numbers and suppliers.
   f. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
   g. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the programming editor.
   h. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.
   i. A listing and documentation of all custom software for the Project created using the programming language, including the set points, tuning parameters, and point and object database.
   j. English language control sequences updated to reflect final programming installed in the BAS at the time of system acceptance.
   k. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.
2. Complete original issue electronic copy for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
3. Complete electronic copy of BAS database, user screens, setpoints and all configuration settings necessary to allow re-installation of system after crash or replacement of server, and resume operations with the BAS in the same configuration as during owner sign-off.
4. Project Record Drawings
   a. As-built versions of the submittal drawings in reproducible paper and electronic format per Paragraph 1.7C.

b. As-built network architecture drawings showing all BACnet nodes including a description field with specific controller and device identification, description and location information.

5. Commissioning Reports. Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc., per Paragraph 3.14A.9.
6. Copy of inspection certificates provided by the local code authorities.
7. Written guarantee and warranty documents for all equipment and systems, including the start and end date for each.
8. Training materials as required by Paragraph **3.15D**.
9. Contact information. Names, addresses, and 24-hour telephone numbers of contractors installing equipment, and the control systems and service representatives of each.

C. Format of Completion Documents

1. Provide the type and quantity of media listed in table below.
2. Project database, programming source files, and all other files required to modify, maintain, or enhance the installed system shall be provided in their source format and compiled format (where applicable).
3. Where electronic copies are specified, comply with the following:
   a. Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf), and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable.
   b. For submittals, provide separate file for each type of equipment.
   c. Control sequences shall be in MS Word.

	Document	Paper (binder or bound)	Electronic	
			Loaded onto Flash Drive	Loaded onto CSS
1.	O&M Manual	2	1	1
2.	Original issue software	–	1 per workstation	1
3.	Project database including all source files	–	1 per workstation	1
4.	Project Record Drawings	2	1	1
5.	Control sequences	1	1	1
6.	Commissioning Reports	2	1	1
7.	Inspection Certificates	1	–	–
8.	Warranty documents	1	–	–
9.	Training materials	1 per trainee	1	1
10.	Contact information	1	–	1

D. Permanent On-site Documentation

1. In panels, provide the following in a sufficiently permanent manner such that documentation cannot be easily removed (and lost):
   a. Point list of all points in panel.
   b. Shop drawings for devices in panel.

1.8 BAS DESIGN

A. System Architecture

1. General
    a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified in this Section. Include all items not specifically itemized in this Section that are necessary to implement, maintain, and operate the system in compliance with the functional intent of this Section.
    b. The system shall be configured as a distributed processing network(s) capable of expansion as specified herein.
    c. The existing Campus BAS consists of a control system server interconnected by a high speed Supervisory LAN to each campus building and facility. This project includes integrating building level BCs and other control devices into the campus system.
        1) Within the building, the BAS shall be standalone and not rely on any 3rd party networks, such as the Campus IT LAN.
        2) To communicate with the central CSS (and internet via VPN), the building Supervisory LAN shall connect via router, provided under Division 25, to the Campus IT LAN, provided by the Owner's IT group. Locate in building BDF.
    d. All control products provided for this Project shall comprise an interoperable Native BACnet System. All control products provided for this Project shall conform to ANSI/ASHRAE Standard 135.
2. BAS Network Architecture
    a. Supervisory LAN: The LAN shall be an Ethernet-based, 100 or 1000 Mbps network connecting the server and OWS(s) and to certain gateways as specified herein. Provide this as a dedicated LAN for the control system; the Owner's IT LAN shall not be used for this purpose. LAN shall be IEEE 802.3 Ethernet with switches and routers that support 100 Mbps minimum throughput. Power-line carrier communication are not acceptable for communications. This network shall be BACnet/IP as defined in the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet.
        1) Supervisory LAN shall be extended to the following mechanical rooms (to allow POTs to connect to system using browser and to improve throughput of trend date)
            a) BDF room
            b) Penthouse main fan room
    b. Primary Controller LAN (Primary LAN): High-speed, peer-to-peer communicating LAN used to connect BCs, AACs, and certain gateways where specified herein. The Primary LAN communicates exclusively control information. Acceptable technologies include and are limited to:
        1) Ethernet (IEEE802.3)
        2) ARCNET (IEEE802.4)
    c. Secondary Controller LAN (Secondary LAN): Network used to connect ASCs and certain gateways where specified herein. These may be Master Slave/ Token Passing (MS/TP) in addition to those allowed for Primary Controller LANs. Network speed versus the number of controllers on the LAN shall be dictated by the response time and trending requirements.
3. Operator Interfaces and Servers. The Control Systems Server (CSS) and Operator interface devices are existing. No additional CSS, OWS, or POT shall be provided as a part of this project. See Paragraph 1.8B for temporary CSS requirements.
4. Controllers. The BCs, AACs, and ASCs shall monitor, control, and provide the field interface for all points specified.
5. Gateways
    a. See Paragraph 2.4C for a list of gateways and routers.
    b. Where gateways are used, critical points shall be hardwired from the BAS to the controlled device, rather than using the gateway, to avoid problems with gateway failures, currently a common problem. Critical points are those that are essential for

proper operation and are listed in points list as separate points. Where listed, these points shall be hardwired even when available through gateway.

B. Integration with Existing System
   1. Include all services required to integrate this building into existing BAS for a fully operational system.
   2. Procedure
      a. Provide all controls work within the building as indicated on Drawings and in this Section.
      b. Develop all building level control system databases and control programming using existing standards and standard programming.
      c. Install building databases and control programming on a temporary portable operator's terminal provided by the Contractor. The POT shall be used for start-up, testing, and commissioning. The POT shall remain the property of the Contractor after final completion of the project.
      d. Once the building BAS has been fully commissioned and accepted by the Owner, merge database and programming with those existing on the Control System Servers. Confirm that the merge was successful by sample testing points and sequences, and approve final installation in writing.
      e. Integrate graphic screens into the Central Plant graphics including adding appropriate hyperlinks so that the system operates as one integrated system.
      f. Provide high level password for Owner operator access to the system only at this point; Owner will not have access to the system prior to system acceptance and integration.

C. System Performance
   1. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. This includes when system is collecting trend data for commissioning and for long term monitoring. (See Paragraph 3.14H.) In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity. Reconfigure LAN as necessary to accomplish these performance requirements. This does not apply to gateways and their interaction with non-BAS-vendor equipment.
      a. Object Command: The maximum time between an operator command via the operator interface to change an analog or binary point and the subsequent change in the controller shall be less than 5 seconds.
      b. Object Scan: All changes of state and change of analog values will be transmitted over the network such that any data used or displayed at a controller or workstation will have been current within the previous 10 seconds.
      c. Graphics Scan: The maximum time between an operator's selection of a graphic and it completely painting the screen and updating at least 10 points shall be less than 10 seconds.
      d. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation or broadcast (where so programmed) shall not exceed 10 seconds for a Level 1 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm levels 4 and 5. All workstations on the onsite network must receive alarms within 5 seconds of each other.
      e. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
      f. Control Loop Performance: Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The

controller shall scan and update the process value and output generated by this calculation at this same frequency.

2. Sensor selection, wiring method, use of transmitters, A-to-D conversion bits, etc. shall be selected and adjusted to provide end-to-end (fluid to display) accuracy at or better than those listed in the following table.

Measured Variable	**Reported Accuracy**
Space drybulb temperature	±1ºF
Ducted Air drybulb temperature	±0.5ºF
Mixed Air drybulb temperature	±1ºF
Outside Air drybulb temperature	±0.5ºF
Chilled and Condenser Water Temperature	±0.2ºF
Hot Water Temperature	±0.5ºF
Relative Humidity − general	±5% RH
Relative Humidity − outdoor air	±3% RH
Water and Gas Flow	±1% of reading
Airflow (terminal)	±10% of reading
Airflow (measuring stations)	±5% of reading
Air Pressure (ducts)	±0.05 inches
Air Pressure (space)	±0.01 inches
Water Pressure	±2% of reading
Electrical power	1% of reading
Carbon Dioxide (CO_2)	±75 ppm

1.9 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:
   1. Project graphic images
   2. Record drawings
   3. Project database
   4. Project-specific application programming code
   5. All documentation

1.10 WARRANTY

A. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the Owner and if all completion requirements per Paragraph 1.7B have been fulfilled, the Owner shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.

B. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for the following periods from date of acceptance:
   1. BCs, AACs, and ASCs: two years
   2. Valve and damper actuators: five years
   3. All else: one year

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies shall be provided at no cost to the Owner during the warranty period.

F. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall be provided at no additional cost to the Owner during this period.

1.11 WARRANTY MAINTENANCE

A. The Owner reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

B. At no cost to the Owner, provide maintenance services for software and hardware components during the warranty period as specified below:
   1. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner to the Contractor.
      a. Response by telephone or via internet connection to the BAS to any request for service shall be provided within two hours of the Owner's initial request for service.
      b. In the event that the malfunction, failure, or defect is not corrected, at least one technician, trained in the system to be serviced, shall be dispatched to the Owner's site within eight hours of the Owner's initial request for such services.
   2. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner to the Contractor.
      a. Response by telephone to any request for service shall be provided within eight working hours (contractor specified 40 hr. per week normal working period) of the Owner's initial request for service.
      b. In the event that the malfunction, failure, or defect is not, at least one technician, trained in the system to be serviced, shall be dispatched to the Owner's site within three working days of the Owner's initial request for such services, as specified.
   3. Owner's Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers/SMS can be used for technicians trained in system to be serviced. One of the three paged/texted technicians shall respond to every call within 15 minutes.
   4. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.
   5. Documentation: Record drawings and software documentation shall be updated as required to reflect any and all changes made to the system or programming during the warranty period.

PART 2 PRODUCTS

2.1 PRIMARY BAS MANUFACTURER

A. Primary BAS manufacturers shall meet the following minimum qualifications:
   1. The manufacturer agrees to fully program and test all ASHRAE Guideline 36 sequences that are referenced herein for their dealers bidding this project at no direct cost to these dealers. The cost of Guideline 36 programming and testing shall not be a direct cost to this project.
   2. The manufacturer has a minimum of three dealers who can bid on this project for this bid, all future improvements, and all future service work. Manufacturers whose dealers produce fewer than 2 bids on this project will be disqualified.

B. The following primary BAS manufacturers are known to meet the above criteria:
   1. Automated Logic Corp.
   2. Distech Controls
   3. Or equal meeting above criteria

2.2 GENERAL

A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way.

B. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

C. All controllers, associated hardware (repeaters, routers, etc.), sensors, and control devices shall be fully operational and maintain specified accuracy at the anticipated ambient conditions of the installed location as follows:
   1. Outdoors or in harsh ambient conditions: -20°C to 55°C (-4°F to 130°F), 10% RH to 90% RH noncondensing.
   2. Conditioned spaces or mechanical rooms: 0°C to 40°C (32°F to 104°F), 10% RH to 80% RH noncondensing.

2.3 CONTROLLERS

A. Building Controller (BC)
   1. ALC OptiFlex line
   2. Distech ECY series or EC-BOS-8

B. Advanced Application Specific Controller (AAC)
   1. ALC SE-series
   2. Distech ECY or ECB series

C. Application Specific Controller (ASC)
   1. ALC ZN-series
   2. Distech ECY or ECB series

2.4 COMMUNICATION DEVICES

A. Supervisory LAN Routers
   1. ALC Optiflex line
   2. Distech ECY series or EC-BOS-8

B. BACnet Gateways & Routers
   1. Gateways shall be provided to link non-BACnet control products to the BACnet inter-network. All of the functionality described in this Paragraph is to be provided by using the BACnet capabilities. Each Gateway shall have the ability to expand the number of BACnet objects of each type supported by 20% to accommodate future system changes.
   2. Each Gateway shall provide values for all points on the non-BACnet side of the Gateway to BACnet devices as if the values were originating from BACnet objects. The Gateway shall also provide a way for BACnet devices to modify (write) all points specified by the Points List using standard BACnet services.

C. Gateway and Routers

Equipment/System	Interface			
	Type	Specified Under Division:	Location	Connect to this Network:
Variable Speed Drives	BACnet/MSTP	23	Each VFD	Secondary
Lighting Controls	BACnet/IP	26	BDF Room	Supervisory
Power Monitoring	BACnet/IP	26	BDF Room	Supervisory
BTU meters	BACnet/MSTP	25	Each BTU meter	Secondary
Emergency Generator	Modbus RS-485	26	Generator yard	Secondary

2.5 BAS INTERFACE HARDWARE

A. Control System Server (CSS) and all other interface hardware is provided under Laney Central Utility Plant scope. No work in this section other than integration of database per Paragraph 1.8B.

2.6 AIR TUBING

A. Seamless copper tubing, Type L-ACR, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder.

B. Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

2.7 ELECTRIC WIRING AND DEVICES

A. All electrical work shall comply with Division 26.

B. Communication Wiring
   1. Provide all communication wiring between Building Controllers, Routers, Gateways, AACs, ASCs and local and remote peripherals (such as operator workstations and printers).

2. Ethernet LAN: Use Fiber or Category 5e or 6 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over 30 volts.
3. ARCnet and MS/TP LAN: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over 30 volts. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

C. Analog Signal Wiring
1. Input and output signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, current or voltage analog outputs, etc. shall be twisted pair, 100% shielded if recommended or required by controller manufacturer, with PVC cover. Gauge shall be as recommended by controller manufacturer.

2.8 CONTROL CABINETS

A. All control cabinets shall be fully enclosed with hinged door.
1. For panels in mechanical rooms and other spaces that are secure and accessible only to BAS/MEP operators, provide quarter-turn slotted latch.
2. For panels located in electrical rooms, IDF rooms, and other spaces that may be accessible by persons other than BAS/MEP operators, provide key-lock latch. A single key shall be common to all panels within each building. Provide 3 keys.

B. Construction
1. Indoor: NEMA 1
2. Outdoor: NEMA 3R

C. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.

D. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

E. Provide with
1. Framed, plastic-encased point list for all points in cabinet.
2. Nameplates for all devices on face.

2.9 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. The listing of several sensors or devices in this section does not imply that any may be used. Refer to points list in Paragraph 2.12 Points List for device specification. Only where two or more devices are specifically listed in points list (such as “FM-1 or FM-4”) may the Contractor choose among listed products.

B. Control Valves
1. Manufacturers
a. Belimo

b. Siemens
c. Invensys
d. Delta
e. Bray
f. Or equal

2. Butterfly Valves
   a. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class bolt pattern to match specified flanges.
   b. Seat: EPDM replaceable, non-collapsible, phenolic backed.
   c. Disc: Polished aluminum bronze or stainless steel, pinned or mechanically locked to shaft. Sanded castings are not acceptable.
   d. Bearings: Bronze or stainless steel.
   e. Shaft: 416 stainless steel supported at three locations with PTFE bushings for positive shaft alignment.
   f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   g. Manufacturers (In Addition to Paragraph 2.9B.1.)
      1) Jamesbury
      2) Keystone
      3) Dezurik
      4) Or equal
3. Two Position Ball Valves
   a. Valves shall be specifically designed for two-position duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and female NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (1 inch and smaller) or 400 psi rating (larger than 1 inch). The stem packing shall consist of 2 lubricated O-rings designed for on-off service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. No characterization disks
   f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   g. Ball: Chrome plated brass
   h. Stem: Chrome plated brass
4. Modulating Characterized Ball Valves
   a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and female NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (2-way valves) or 400 psi rating (3-way valves). The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   f. Ball: stainless steel
   g. Stem: stainless steel
   h. Characterizing disk held securely by a keyed ring providing equal percentage characteristic
5. Minimum valve assembly pressure ratings
   a. Chilled water: 125 psi at 60ºF
   b. Hot water: 125 psi at 200ºF
   c. Condenser water: 125 psi at 100ºF
6. Valve Selection

a. Valve type
   1) Modulating 2-way or 3-way valves: characterized ball type
   2) Two-position isolation: butterfly or non-characterized ball type
b. Valve Characteristic
   1) 2-way valves: equal percentage or modified equal percentage.
   2) 3-way valves controlling cooling coils and condenser water heat exchangers: linear.
   3) 3-way valves controlling heating coils: equal percentage or modified equal percentage.
   4) Two-position valves: not applicable. For ball valves used for two-position duty, do not include characterizing disk.
c. Valve Sizing
   1) Modulating Water: Size valve to achieve the following full-open pressure drop
      a) Minimum pressure drop: equal to half the pressure drop of coil or exchanger.
      b) Maximum pressure drop
         1. Hot water at coils: 2 psi
         2. Chilled water at coils: 5 psi
      c) 3-way valves shall be selected for near minimum pressure drop. 2-way and 6-way valves shall be selected near maximum pressure drop.
      d) Flow coefficient (C_v) shall not be less than 1.0 (to avoid clogging) unless protected by strainer. Verify from piping schematics that a strainer is being provided.
      e) Valve size shall match as close as possible the pipe size where C_v is available in that size.
   2) Two-position valves: Line size unless otherwise indicated on Drawings.

C. Control Dampers
   1. See Section 233300 Duct Accessories and Section 237300 Air Handling Units & Coils.

D. Actuators
   1. Manufacturers
      a. Belimo
      b. No equal
   2. Warranty: Valve and damper actuators shall carry a manufacturer's 5-year warranty.
   3. Electric Actuators
      a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
      b. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
      c. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
      d. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.
      e. Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
      f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.
      g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical

paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.

h. Modulating Actuators. Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a floating actuator with an analog signal converter are not acceptable.

i. Where indicated on Drawings or Points List, actuators shall include
   1) 2 to 10 VDC position feedback signal
   2) Limit (end) position switches

j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.

k. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

l. Actuators shall be provided with a conduit fitting an a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

m. Where fail-open or fail-closed (fail-safe) position is required by Paragraph 2.9D.5, an internal mechanical, spring return mechanism shall be built into the actuator housing. Electrical capacitor type fail-safe are also acceptable. All fail-safe actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.

n. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.

o. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.

p. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.

q. Actuators shall provide clear visual indication of damper/valve position.

4. Electric Actuators for Large Butterfly Valves

a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.

b. The valve actuator shall consist of a capacitor-type reversible electric motor, gear train, limit switches and terminal block, all contained in a die cast aluminum enclosure.

c. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.

d. Output shaft shall be electroless nickel plated to prevent corrosion.

e. Actuator shall have a motor rated for minimum 75% duty cycle. Duty cycle shall be defined as running time divided by installed time at maximum torque.

f. Actuator shall be suitable for operation in ambient temperature ranging from -22°F to +150°F.

g. A pre-wired cable shall bring wiring outside enclosure to avoid necessity of opening cover.

h. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.

i. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator. When in manual operation electrical power to the actuator will be permanently interrupted.

j. The hand wheel will not rotate while the actuator is electrically driven.

k. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
l. Provide limit (end) position switches where indicated on schematics.
m. Actuators shall provide clear visual indication of valve position.

5. Normal and Fail-Safe Position
   a. Except as specified otherwise herein, the normal position (that with zero control signal) and the fail-safe position (that with no power to the actuator) of control devices and actuators shall be as indicated in table below. "Last" means last position. Actuators with a fail-safe position other than "Last" must have spring or electronic fail-safe capability.

Device	**Normal Position**	**Fail-Safe Position**
Outside air damper	CLOSED	OPEN (for life safety)
Return air damper (Note 1)	OPEN	CLOSED (for life safety)
Exhaust/relief air damper (Note 2)	CLOSED	OPEN (for life safety)
AHU heating coil valves	OPEN	LAST
AHU cooling coil valves	CLOSED	LAST
HW/CHW valves for changeover coils	Same as fail-safe	See Schematics
VAV box dampers	OPEN	LAST
Notes: 1. Actuators shall be provided with damper as a UL listed smoke damper assembly under Section 237300 Air Handling Units & Coils. 2. Actuators shall be rated for 200°F ambient temperature minimum, e.g. Belimo FSAF series for smoke exhaust operation		

6. Valve Actuator Selection
   a. Modulating actuators for valves shall have minimum rangeability of 50 to 1.
   b. Water
      1) 2-way, 6-way, and two-position valves
         a) Tight closing against 125% of system pump shut-off head.
         b) Modulating duty against 90% of system pump shut-off head.
      2) 3-way shall be tight closing against twice the full open differential pressure for which they are sized.
7. Damper Actuator Selection
   a. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.
   b. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer's recommendations and the following:
      1) Torque shall be a minimum 5 inch-pound per square foot for opposed blade dampers and 7 inch-pound per square foot for parallel blade dampers.
      2) The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating.

E. General Field Devices
   1. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
   2. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

3. Field devices specified herein are generally two-wire type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with two-wire type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, provide a transmitter and necessary regulated DC power supply, as required.
4. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.
5. Accuracy: As used in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis. Sensor accuracy shall be at or better than both that specifically listed for a device and as required by Paragraph 1.8C.2.

F. Temperature Sensors (TS)
1. General
   a. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.
   b. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3ºF (0.16 °C) (unless noted otherwise herein).
   c. Sensors shall drift no more than 0.3ºF and shall not require calibration over a five-year period.
   d. Manufacturers
      1) Mamac
      2) Kele Associates
      3) Building Automation Products Inc.
      4) Automated Logic Corp.
      5) Or equal
2. Duct temperature sensors: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.
   a. TS-1A: Single point (use where not specifically called out to be averaging in points list). Sensor probe shall be 304 stainless steel.
   b. TS-1B: Averaging. Sensor length shall be at least 1 linear foot for each 2 square feet of face area up to 25 feet maximum. Sensor probe shall be bendable aluminum.
3. Water Temperature Sensors
   a. TS-2A: Well mounted immersion sensor, ¼" stainless steel probe, double encapsulated sensor, with enclosure suitable for location.
   b. TS-2B: Same as TS-2A except provide extra precision (XP) temperature sensors to meet accuracy specified Paragraph 1.8C.2.
   c. TS-2C. See BTU-1.
   d. All piping immersion sensors shall be in one-piece machined brass or stainless steel wells that allow removal from operating system, with lagging extension equal to insulation thickness where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature and fluid velocity. The well shall penetrate the pipe by the lesser of approximately half the pipe diameter or eight inches. The use of direct immersion or strap-on type sensors is not acceptable.
4. Room Sensors
   a. Thermostat tags refer to the following:

Type:	Tag	
ALC model	ZS2 Standard	ZS2 Pro
Distech model	EC-SmartAir	EC-SmartVue
Display	Blank	LCD

Temperature only	TS-3A	TS-3C
With humidity	TS-3AH	TS-3CH
With CO_2	TS-3AC	TS-3CC
With CO_2 and humidity	TS-3AHC	TS-3CHC

1) Display
   a) Blank: Blank cover (or LCD display with display configured to be shut off and touchpad or keypad disabled)
   b) LCD: LCD display of all sensors, temperature setpoint adjustment buttons, and schedule override button
2) Humidity Sensor
   a) 10% to 90%/±2% accuracy
   b) Where humidity sensor is not specified but included as standard, it shall be configured to not be displayed on the LCD or any graphics and not included in points list, as if it did not exist. (The purpose is to avoid the expense of having to keep the sensor in calibration.)
3) CO2 Sensor
   a) 400 to 1250 PPM/ ±30PPM or 3% of reading, whichever is greater.
   b) The sensor shall include automatic background calibration (ABC) logic to compensate for the aging of the infrared source and shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the Owner within 5 years of purchase date.
   c) Meet Title 24 requirements including calibration interval
4) For room sensors connected to terminal box controllers (such as at VAV boxes) that require calibration: Include a USB port or some other means for connection of POT for terminal box calibration. Alternative means of terminal calibration are acceptable provided they result in no cost to Work performed under Section 230593 Testing, Adjusting, and Balancing.

b. See equipment schedules for thermostat type.

5. TS-4: Outdoor Air Sensor
   a. Outdoor air sensors shall have a sun shield, utility box, and watertight gasket to prevent water seepage.
6. Temperature Transmitters: Where required by the Controller or to meet specified end-to-end accuracy requirements, sensors as specified above shall be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1°F when applied to the sensor range.

G. BTU Meter (BTU-1)
1. Matched RTD or solid state temperature sensors with a differential temperature accuracy of +/-0.15°F.
2. Flow meter: FM-1
3. Unit accuracy shall be +/- 1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. UL listed.
6. Provide BACnet/MSTP network connection that will allow all point data to be transmitted to BAS network.
   a. BACnet Points:
      1) Supply Temperature
      2) Return Temperature
      3) Flow
      4) Energy Rate (Btu/hr.)
7. Manufacturers
   a. Onicon System 20

b. Siemens Sitrans
c. Or Equal

H. Differential Pressure Transmitters (DPT)
1. DPT-1: Water, General Purpose
a. Fast-response capacitance sensor
b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
c. Accuracy
1) Overall Accuracy (at constant temp) ±0.25% full scale (FS).
2) Non-Linearity, BFSL ±0.22% FS.
3) Hysteresis 0.10% FS.
4) Non-Repeatability 0.05% FS.
d. Long Term Stability 0.5% FS per year
e. Only 316 stainless steel in contact with fluid
f. Pressure Limits
1) 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.
2) 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.
g. Include brass 5-valve assembly for single sensor devices. See Paragraph 3.11E.7.
h. Manufacturers
1) Setra 209 or 230
2) Modus W30
3) Or equal
2. DPT-2: Not used
3. DPT-3: Air, Duct Pressure:
a. General: Loop powered two-wire differential capacitance cell-type transmitter.
b. Output: two wire 4-20 mA output with zero adjustment.
c. Overall Accuracy: ±1% of range (not of maximum range/scale)
d. Switch selectable range:
1) ≥ 0.5 inches water column
2) ≤10 inches water column
3) Select range as specified in points list or, if not listed for specified setpoint to be between 25% and 75% full-scale.
e. Housing: Polymer housing suitable for surface mounting.
f. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301, Davis Instruments, or equal, with connecting tubing.
g. DPT-3A: Include LCD display of reading.
h. Manufacturers.
1) Setra
2) Modus
3) Invensys
4) Dwyer
5) Or equal
4. DPT-4: Air, Low Differential Pressure
a. General: Loop powered, two-wire differential capacitance cell type transmitter.
b. Output: Two-wire 4-20 mA output with zero adjustment.
c. Overall Accuracy
1) General: ±1% FS
2) Underfloor: ±0.5% FS
3) Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS
d. Range
1) Fixed (non-switch selectable)
2) Minimum Range: 0, -0.1, -0.25, -0.5, or -1.0 inches water column

3) Maximum Range: +0.1, 0.25, 0.5, or 1.0 inches water column
4) Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.

e. Housing: Polymer housing suitable for surface mounting
f. Static Sensing Element
1) Ambient sensor: Dwyer A-306 or 420, BAPI ZPS-ACC-10, or equal
2) Space sensor: Kele RPS-W, BAPI ZPS-ACC-01, Dwyer A-417 or 465, Veris AA05 or equal wall plate sensor
3) Filter or duct pressure sensor: Dwyer A-301 or equal
4) Plenum pressure sensor: Dwyer A-421 or equal
g. DPT-4A: Include LCD display of reading
h. Manufacturers
1) Setra 267
2) Modus
3) Air Monitor
4) Paragon
5) Or equal

5. DPT-5: VAV Velocity Pressure
a. General: Loop powered two-wire differential capacitance cell type transmitter.
b. Output: Two-wire, 4-20 mA output with zero adjustment.
c. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004 inches differential pressure or lower, shall be capable of sensing 0.002 inches differential pressure or lower, and shall have a ±0.001 inches or lower resolution across the entire scale.
d. Calibration software shall use a minimum of two field measured points, minimum and maximum airflow, with curve fitting airflow interpolation in between.
e. Range: 0 to 1.5 in.w.c.
f. Housing: Polymer housing suitable for surface mounting.
g. Manufacturer
1) Automated Logic or Distech
2) No equal

I. Differential Pressure Switches (DPS)
1. DPS-1: Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0ºF to 160ºF operating temperature range.
2. DPS-2: Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Automatic reset. Provide manufacturer's recommended static pressure sensing tips and connecting tubing.

J. Current Switches (CS-1)
1. Clamp-on or solid-core
2. Range: as required by application
3. Trip Point: Automatic or adjustable
a. Exception: Fixed setpoint (Veris H-300 or equal) may be used on direct drive constant speed fans that do not have backdraft or motorized shutoff dampers.
4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage
5. Lower Frequency Limit: 6 Hz
6. Trip Indication: LED
7. Approvals: UL, CSA
8. May be combined with relay for start/stop
9. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing with override switch. Kele RIBX, Veris H500, or equal

10. Manufacturers
    a. Veris Industries H-608/708/808/908, and H6ECM05 for ECMs
    b. Senva C-2320L
    c. RE Technologies SCS1150A-LED
    d. Or equal

K. Current Transformers (CT-1)
1. Clamp-On Design Current Transformer (for Motor Current Sensing)
2. Range: 1-10 amps minimum, 20-200 amps maximum
3. Trip Point: Adjustable
4. Output: 0-5 Vdc or 0-10 Vdc,
5. Accuracy: ±0.2% from 20 to 100 Hz.
6. Amperage range sizing and switch settings in accordance with the following and per manufacturer's instructions:

Motor HP	120V	277V	480V
≤1/2	0-10A	0-10A	–
3/4 – 1.5	–	0-10A	0-10A
2 – 5	–	–	0-10A
7.5 – 10	–	–	0-20A
15 – 20	–	–	0-30A
25 – 30	–	–	0-40A

7. Manufacturers
    a. Veris Hx22 series
    b. Kele SC100
    c. Or equal

L. Flow Meter (FM)
1. FM-1: Magnetic Flow Tube Flow Meters
    a. General Requirements
        1) Sensor shall be a magnetic flow meter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
        2) Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
        3) Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used on HVAC applications provided accuracy is as specified.
        4) Flow Tube
            a) ANSI class 150 psig steel
            b) ANSI flanges
            c) Lined with
                1. Heating hot water, glycol: PTFE, PFA, or ETFE liner rated for ≤-4°F to ≥212ºF fluid temperature
                2. Chilled, condenser, domestic hot and cold water: Polypropylene, Ebonite, PTFE, PFA, or ETFE liner rated for ≤32°F to ≥140ºF fluid temperature
        5) Electrode and grounding material
            a) 316L Stainless steel or Hastelloy C
            b) Electrodes shall be fused to ceramic liner and not require O-rings.

6) Electrical Enclosure: NEMA 4
7) Approvals
   a) UL or CSA
   b) NSF Drinking Water approval for domestic water applications
8) Performance
   a) Accuracy shall be ±0.5% of actual reading from 3 to 30 feet per second flow velocities, and ±0.015 fps from 0.04 fps to 3 fps.
   b) Stability: 0.1% of rate over six months.
   c) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.
   d) Calibration: The sensor must be factory calibrated on an internationally accredited (such as NAMAS) water flow rig with accuracy better than 0.1%. Calibration shall be NIST traceable.

b. Manufacturers
   1) Onicon F-3100 series
   2) Siemens/Danfoss Magflo 3100
   3) Krohne Optiflux 4000
   4) Sparling TigermagEP FM656
   5) Or equal

2. FM-2: Not used
3. FM-3: Not used
4. FM-4: Not used
5. FM-5: Not used
6. FM-6: Domestic and makeup water meters
   a. 2 inches and smaller: Multi-jet water meter
      1) Multi-jet velocity type meter
      2) Magnetic drive – no gearing exposed to water
      3) 125 psi cast bronze body with integral strainer
      4) Meet all requirements of AWWA C-708 Multi-Jet Meter
      5) Accuracy: ±1.5% of reading
      6) Low voltage pulse output, with configurable volume per pulse.
      7) pulse output
      8) Odometer-type gallons totalizer display with weather cover
      9) Designed for vertical or horizontal piping
      10) For potable water: NSF-61 certified and in compliance with California Proposition 65
      11) Manufacturers:
         a) SeaMetrics MJE, MJR, or WTS
         b) Elster Amco M700
         c) Master Meter
         d) Equal
   b. 2.5 inches and larger: Compound-type water meter
      1) Shall consist of a combination of a turbine-type, mainline meter for measuring high rates of flow and a bypass meter of an appropriate size for measuring low rates of flow. The compound meter shall have an automatic valve mechanism for diverting low rates of flow through the bypass meter.
      2) Comply with ANSI and AWWA C702 standards.
      3) Comply with NSF/ANSI Standard 61, ANNEX G.
      4) Maximum operating pressure of 150 psi and maximum operating temperature of 120°F continuous (220°F peak).
      5) Low voltage pulse output, with configurable volume per pulse.
      6) Manufacturers:
         a) Badger Recordall Series Meter
         b) Neptune
         c) Or equal

M. Airflow Measuring Stations (AFMS)
   1. General. AFMS provided under this Section shall be licensed to bear the AMCA Certified Rating Seal for Airflow Measuring Stations. Ratings shall be based on tests and procedures performed in accordance with AMCA Publication 611 and comply with requirements of the AMCA Certified Ratings Program.
   2. AFMS-1
      a. Differential pressure type with uniframe DP sensor
         1) Provide quantity of DP sensors per manufacturer's recommendations
      b. Station mounted with expanded metal screen
      c. Analog outputs for airflow and temperature
      d. Manufacturers
         1) Air Monitor OAM-II-AFS
         2) No equal

N. Electric Control Components
   1. Line-Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT contacts rated for 120V and current as required for application, temperature setpoint range of 50 to 95ºF, and an adjustable 2-10ºF setpoint differential.
   2. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
      a. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
         1) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
         2) Coil sealed volt-amperes (VA) not greater than 4 VA.
         3) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
         4) Pilot light indication of power-to-coil and coil retainer clips.
      b. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load.
      c. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
   3. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square D, Cutler-Hammer, or equal.
   4. Control Transformers and Power Supplies
      a. Control transformers shall be UL Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Mount in minimum NEMA-1 enclosure.
      b. Transformer shall be proper size for application. Limit connected loads to 80% of rated capacity.
      c. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
      d. Separate power transformer shall be used for controllers and for actuators and other end devices that use half wave rectification.
      e. Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.
      f. Line voltage units shall be UL Recognized and CSA Approved.

5. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley, Kele, or equal.
6. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley, Kele, or equal.

2.10 CALIBRATION & TESTING INSTRUMENTATION

A. Provide instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (for example if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

2.11 SOFTWARE

A. General
1. System software shall be the latest version of ALC WebCTRL or Distech EC-Net.

B. Licensing
1. Include licensing and hardware keys for all software packages at all workstations (OWSs and POTs) and servers.
2. Within the limitations of the server, provide licenses for any number of users to have web access to the CSS at any given time.
3. All operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.
4. All operator software, including that for programming and configuration, shall be available on all workstations. Hardware and software keys to provide all rights shall be installed on all workstations.

C. Graphical User Interface Software
1. Graphics
   a. The GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated graphics and active setpoint graphic controls shall be used to enhance usability.
   b. Graphics tools used to create Web Browser graphics shall be non-proprietary and provided and installed on each OWS.
   c. Graphical display shall be 1280 x 1024 pixels or denser, 256 color minimum.
   d. Links
      1) Graphics shall include hyperlinks which when selected (clicked on with mouse button) launch applications, initiate other graphics, etc.
      2) Screen Penetration: Links shall be provided to allow user to navigate graphics logically without having to navigate back to the home graphic. See additional discussion in Paragraph 3.12E.
      3) Information Links

a) On each MEP system and subsystem graphic, provide links to display in a new window the information listed below.
1. English-language as-built control sequence associated with the system. See Paragraph 1.7B.
2. O&M and submittal information for the devices on the graphic. See Paragraph 1.7B. This includes links to electronic O&M and submittal information for mechanical equipment supplied under Section 230501 Basic Mechanical Materials and Methods.
b) The display shall identify the target of the link by file name/address.
c) Information shall be displayed in electronic format that is text searchable.
d) Window shall include software tools so that text, model numbers, or point names may be found. Source documents shall be read-only (not be editable) with this software.

e. Point Override Feature
1) Every real output or virtual point displayed on a graphic shall be capable of being overridden by the user (subject to security level access) by mouse point-and-click from the graphic without having to open another program or view.
2) When the point is selected to be commanded
a) Dialog box opens to allow user to override the point (Operator Mode) or release the point (Automatic Mode). Operator Mode will override automatic control of the point from normal control programs.
b) Dialog box shall have buttons (for digital points) or a text box or slide bar (for analog points) to allow user to set the point's value when in operator mode. These are grayed out when in automatic mode.
c) When dialog box is closed, mode and value are sent to controller.
d) Graphic is updated upon next upload scan of the actual point value.
3) A list of points that are currently in an operator mode shall be available through menu selection.

f. Point override status (if a digital point is overridden by the supervised manual override per Paragraph 2.3A or if a point is in operator mode per Paragraph 2.11C.1.e) shall be clearly displayed on graphics for each point, such as by changing color or flag.

g. The color of symbols representing equipment shall be able to change color or become animated based on status of binary point to graphically represent on/off status.

2. Alarms
a. ALC WebCTRL Enterprise Integration advanced alarm package or Distech EC-Net Alarm Console package configured as indicated below.

3. Trends
a. ALC WebCTRL Enterprise Integration or Distech EC-Net trend package configured as indicated below.
b. Trend Data Storage
1) The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS using SQL queries.
2) Data shall be stored in an SQL compliant database format and shall be available through the Owner's intranet or internet (with appropriate security clearance) without having to disable BAS access to the database.
3) The database shall not be inherently limited in size, e.g. due to software limitations or lack of a correct license. Database size shall be limited only by the size of the provided storage media (hard drive size).

4. Security Access

a. Standard ALC WebCTRL or Distech EC-Net security package

5. Report Software
   a. ALC WebCTRL Enterprise Integration or Distech EC-Net advanced reporting package.
   b. Standard reports. Prepare the following standard reports, accessible automatically without requiring definition by user.
      1) Tenant or department after-hour usage. System must be capable of monitoring tenant override requests and generating a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC services.
      2) Monthly and annual energy usage and cost. See Utility cost calculation in Paragraph 3.12.
      3) Alarm events and status.
      4) Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output, including date and time.

D. Control Programming Software
   1. Standard ALC WebCTRL Eikon programming or Distech EC-gfxProgram

E. Miscellaneous Software
   1. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide relevant data for the application or object that help is being called from.
   2. Provide software for viewing (but not editing) electronic versions of as-built shop drawings of
      a. Mechanical, electrical, and plumbing systems in Adobe pdf format
      b. BAS drawings in Adobe pdf format

2.12 CONTROL POINTS

A. Table Column Definitions
   1. Point description
   2. Type (number in point schedule after each type refers to tag on schematics)
      a. AO: analog output
      b. AI: analog input
      c. DO: digital or binary output
      d. DI: digital or binary input
   3. Device description
      a. See Paragraph 2.9 for device definition.
   4. Trend Logging
      a. Commissioning: Where listed, point is to be trended at the basis listed for commissioning and performance verification purposes.
      b. Continuous: Where listed, point is to be trended at the basis listed continuously, initiated after system acceptance, for the purpose of future diagnostics.
      c. Trend Basis
         1) Where range of engineering units is listed, trend on a change of value (COV) basis (in other words record time stamp and value when point value changes by engineering unit listed).
         2) Where time interval is listed, trend on a time basis (in other words record time stamp and value at interval listed). All points relating to a specific piece of equipment shall be trended at the same initiation time of day so data can be compared in text format.
   5. Calibration

a. F = factory calibration only is required (no field calibration)
b. HH = field calibrate with handheld device. See Paragraph 3.14D.6.a.2)

B. Note that points lists below are for each system of like kind. Refer to drawings for quantity of each.

C. Points mapped through gateways and network interfaces

1. Variable speed drives

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Fault reset	DO	Through network	COV	COV	–
On/off status	DI	Through network	COV	COV	–
Fault (Critical Alarm)	DI	Through network	COV	COV	–
Minor Alarm	DI	Through network	COV	COV	–
Fault Text	DI	Through network (convert code to plain English text)	COV	COV	–
Alarm Text	DI	Through network (convert code to plain English text)	COV	COV	–
Keypad in hand/auto	DI	Through network	COV	COV	–
Minimum frequency setpoint	AO	Through network	±5%	±5%	–
Maximum frequency setpoint	AO	Through network	±5%	±5%	–
Acceleration rate	AO	Through network	±5%	±5%	–
Deceleration rate	AO	Through network	±5%	±5%	–
Actual frequency	AI	Through network	1 min	15 min	–
AC output voltage	AI	Through network	±10%	±10%	F
Current	AI	Through network	15 min	60 min	F
VFD temperature	AI	Through network	60 min	60 min	F
Power, kW	AI	Through network	1 min	15 min	F
Energy, MWh	AI	Through network	15 min	60 min	–

2. Electrical System Monitoring. See Division 26 Drawings for quantity of meters and location of network connection.

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Real kW	AI	Through network	15 min	15 min	–
Volts (each phase)	AI	Through network	±10%	±10%	–
Power factor	AI	Through network	±10%	±10%	–
Amps (each phase)	AI	Through network	–	–	–

3. BTU Meter (BTU-1)

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Return Temperature	AI	Through network	1 min	15 min	F
Supply Temperature	AI	Through network	1 min	15 min	F
Flow	AI	Through network	1 min	15 min	F

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Btu/h	AI	Through network	1 min	15 min	–

4. Lighting Controls
   a. Global

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Demand Shed 1	DO	Through network	COV	COV	–
Demand Shed 2	DO	Through network	COV	COV	–
Demand Shed 3	DO	Through network	COV	COV	–

   b. For each lighting zone

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Occupancy Sensor State	DI	Through network	COV	COV	–

5. Emergency Generator

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Status normal power	DI	Through network	COV	COV	–
Status generator power	DI	Through network	COV	COV	–
Generator running	DI	Through network	COV	COV	–
Generator not in auto	DI	Through network	COV	COV	–
Shut-down summary alarm	DI	Through network	COV	COV	–
Fuel tank alarm – low level	DI	Through network	COV	COV	–
Fuel tank alarm – high level	DI	Through network	COV	COV	–
Fuel tank alarm – rupture	DI	Through network	COV	COV	–
Water temperature alarm	DI	Through network	COV	COV	–
Low DC battery voltage	DI	Through network	COV	COV	–
Battery charger malfunction	DI	Through network	COV	COV	–
Ground fault	DI	Through network	COV	COV	–
Low coolant level	DI	Through network	COV	COV	–
Pre-alarm Low fuel	DI	Through network	COV	COV	–
Pre-alarm high water temperature	DI	Through network	COV	COV	–
Pre-alarm low oil pressure	DI	Through network	COV	COV	–
Over-speed alarm	DI	Through network	COV	COV	–
Over-crank alarm	DI	Through network	COV	COV	–

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
High water temperature alarm	DI	Through network	COV	COV	–
Low oil pressure alarm	DI	Through network	COV	COV	–
Emergency stop alarm	DI	Through network	COV	COV	–
Pre-overload alarm	DI	Through network	COV	COV	–
Overload alarm	DI	Through network	COV	COV	–
AC current Phase 1	AI	Through network	±10%	±10%	–
AC current Phase 2	AI	Through network	±10%	±10%	–
AC current Phase 3	AI	Through network	±10%	±10%	–
AC voltage neutral	AI	Through network	±10%	±10%	–
AC voltage Phase 1	AI	Through network	±10%	±10%	–
AC voltage Phase 2	AI	Through network	±10%	±10%	–
AC voltage Phase 3	AI	Through network	±10%	±10%	–

D. Hardwired Points

1. VAV Box - Cooling only
    a. Note: On floors 1 and 2, provide spring-return actuators configure to open on loss of power. This is required for smoke control makeup.

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
VAV Box Damper Position	AO	Modulating actuator	1 min	15 min	–
Local Override	DI	TS-3x – where applicable (see Paragraph 2.9F).	COV	COV	–
Supply Airflow	AI	DPT-5 connected to box manufacturer supplied flow cross	1 min	15 min	HH (see §230593)
Zone Temperature Setpoint Adjustment	AI	TS-3x – where applicable (see Paragraph 2.9F).	15 min	60 min	F
Zone Temperature	AI	TS-3x (see Paragraph 2.9F)	1 min	15 min	F

2. VAV dual duct zones
    a. Note: On floors 1 and 2, provide spring-return actuators configure to open on loss of power. This is required for smoke control makeup.

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Cooling damper	AO	Modulating actuator	COV	COV	–
Heating damper	AO	Modulating actuator	COV	COV	–
Local Override	DI	TS-3x – where applicable (see Paragraph 2.9F).	COV	COV	–
Zone Temperature Setpoint Adjustment	AI	TS-3x – where applicable (see Paragraph 2.9F).	15 min	60 min	F
Zone Temperature	AI	TS-3x (see Paragraph 2.9F)	1 min	15 min	F

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Cooling air volume	AI	DPT-5 connected to box manufacturer supplied flow cross at cooling inlet	1 min.	10 min.	HH (see §230593)
Heating air volume	AI	DPT-5 connected to box manufacturer supplied flow cross at heating inlet	1 min.	10 min.	HH (see §230593)
CO_2 concentration	AI	TS-3x (see Paragraph 2.9F)	1 min.	10 min.	F

3. VAV Box - Cooling only with Thermafusers

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
VAV Box Damper Position	AO	Modulating actuator	1 min	15 min	–
Duct Static Pressure	AI	DPT-3A, 0 to 0.5 inches	1 min	15 min	F
Supply Airflow	AI	DPT-5 connected to box manufacturer supplied flow cross	1 min	15 min	HH

4. Cooling VAV Air Handler

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Relief damper 1 open/close	DO	Two position actuator	COV	COV	–
Relief damper 2 open/close	DO	Two position actuator	COV	COV	–
Relief Fan 1 Start/Stop	DO	Connect to VFD Run	COV	COV	–
Relief Fan 2 Start/Stop	DO	Connect to VFD Run	COV	COV	–
Supply fan high static alarm reset	DO	Dry contact to 120V or 24V control circuit –see control schematics for details	COV	COV	–
Supply Fan 1 Start/Stop	DO	Connect to VFD Run	COV	COV	–
Supply Fan 2 Start/Stop	DO	Connect to VFD Run	COV	COV	–
Changeover valves	DO	Two position 2-way valves, CW and HW, spring return per drawings	COV	COV	–
Outdoor Air Damper	AO	Modulating actuator	1 min	15 min	–
Return Air Damper	AO	Modulating actuator	1 min	15 min	–
Relief Fan Speed	AO	Connect to VFD Speed, RF-1 and 2	1 min	15 min	–
Supply Fan Speed	AO	Connect to VFD Speed, SF-1 and 2	1 min	15 min	–
Chilled/hot Water Control Valves	AO	Modulating 2-way valves, CHW and HW, spring return closed	1 min	15 min	–
Mixed Air Temperature	AI	TS-1B across filter bank	1 min	15 min	F

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Filter Pressure Drop	AI	DPT-3A, 0 to 1 inch	–	60 min	F
Return Air Temperature	AI	TS-1A	1 min	15 min	F
Outdoor Airflow	AI	AFMS-1, flow output	1 min	15 min	F
Outdoor Temperature	AI	AFMS-1, temperature output	1 min	15 min	F
Supply Air Temperature	AI	TS-1A	1 min	15 min	HH
Duct Static Pressure	AI	DPT-3A, 0 to 2 inches	1 min	15 min	F
Building Pressure, Building, 2nd floor	AI	DPT-4, ±0.25	1 min	15 min	F
Building Pressure, Building, 3rd floor	AI	DPT-4, ±0.25	1 min	15 min	F

5. Heating VAV Air Handler

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Supply fan high static alarm reset	DO	Dry contact to 120V or 24V control circuit –see control schematics for details	COV	COV	–
Supply Fan 1 Start/Stop	DO	Connect to VFD Run	COV	COV	–
Supply Fan 2 Start/Stop	DO	Connect to VFD Run	COV	COV	–
Supply Fan Speed	AO	Connect to VFD Speed, SF-1 and 2	1 min	15 min	–
Hot Water Control Valve	AO	Modulating 2-way valves	1 min	15 min	–
Filter Pressure Drop	AI	DPT-3A, 0 to 1 inch	–	60 min	F
Supply Air Temperature	AI	TS-1A	1 min	15 min	HH
Duct Static Pressure	AI	DPT-3A, 0 to 2 inches	1 min	15 min	F

6. Hot Water Pumps

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Start HWP-1	DO	Connect to VFD Run	COV	COV	–
Start HWP-2	DO	Connect to VFD Run	COV	COV	–
Pump speed	AO	Connect to VFD Speed, HWP-1 and 2	1 min	5 min	–
Hot Water Control Valve	AO	Modulating 2-way valves	1 min	15 min	–
HW differential pressure from plant	AI	DPT-1, 0 to 50 psi	5 min	15 min	F
HW differential pressure in building	AI	DPT-1, 0 to 40 psi	5 min	15 min	F

7. Chilled Water Connection

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
CHW differential pressure from plant	AI	DPT-1, 0 to 50 psi	5 min	15 min	F

8. Domestic Water Heaters

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Recirculation Pumps Start/Stop	DO	Line voltage contact to pump power circuit	COV	COV	–
DHW Supply Temperature	AI	TS-2A	5 min	15 min	F
Recirculation Pump Status	DI	CS-1 OR CT-1	COV	COV	See 3.11F
DHW heater Alarm	DI	Install relay wired downstream of DHW heater safeties with NC relay contact wired as alarm input.	COV	COV	–

9. Toilet Exhaust Fan

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Fan Start/Stop	DO	Dry contact to 120V starter control circuit	COV	COV	–
Fan Status	DI	CS-1 OR CT-1	COV	COV	See 3.11F

10. Miscellaneous Points

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Domestic water flow	AI	FM-6	1 min	15 min	HH
Outdoor Air Temperature	AI	TS-4, located on north wall	1 min	15 min	HH

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

A. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details indicated on Drawings.

B. Coordinate Work and Work schedule with other trades prior to construction.

C. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.

B. Store equipment and materials inside and protect from weather.

3.3 IDENTIFICATION

A. General
1. Manufacturers' nameplates and UL or CSA labels to be visible and legible after equipment is installed.
2. Identifiers shall match record documents.
3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Wiring and Tubing
1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2 inches of termination with the BAS address or termination number.
2. Permanently label or code each point of field terminal strips to show the instrument or item served.
3. All pneumatic tubing shall be labeled at each end within 2 inches of termination with a descriptive identifier.

C. Equipment and Devices
1. Valve and damper actuators: None required.
2. Sensors: Provide 1 inch x 3 inches x 1/8 inches black micarta or lamacoid labels with engraved white lettering, ¼ inches high. Indicate sensor identifier and function (for example "CHWS Temp").
3. Panels
   a. Provide 2 inches x 5 inches 1/8 inches black micarta or lamacoid labels with engraved white lettering, ½ inches high. Indicate panel identifier and service.
   b. Provide permanent tag indicating the electrical panel and circuit number from which panel is powered.
4. Identify room sensors relating to terminal box or valves with indelible marker on sensor hidden by cover.

3.4 CUTTING, CORING, PATCHING AND PAINTING

A. Provide canning for openings in concrete walls and floors and other structural elements prior to their construction.

B. Penetrations through rated walls or floors shall be filled with a listed material to provide a code compliant fire-stop.

C. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Work in this Section shall be properly sealed, repaired, or re-insulated by experienced mechanics of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

D. At the completion of Work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.5 CLEANING

A. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, and other debris generated by Work in this Section as soon as their contents have been removed. Waste shall be collected and legally disposed of.

B. Materials stored on-site shall be protected from weather and stored in an orderly manner, neatly stacked, or piled in the designated area assigned by the Owner's Representative.

C. At the completion of work in any area, clean all work and equipment of dust, dirt, and debris.

D. Use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

3.6 CONTROLLERS

A. General
1. Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details indicated on Drawings.
2. Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. Except as listed below, all physical point data and calculated values required to accomplish the sequence of operation shall reside within the associated CU. Listed below are point data and calculated values that shall be allowed to be obtained from other CUs via LAN.
   a. Global points such as outdoor air temperature
   b. Requests, such as heat/cool requests, used to request operation or for setpoint reset from zones to systems and systems to plants
   c. Modes, such as system modes, used to change operating logic from plants to systems and systems to zones
3. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

B. Controller Application Categories
1. Controllers shall comply with the application table below (X under controller type indicates acceptable controller type).

Application Category	Examples	Acceptable Controller		
		ASC	AAC	BC
0	Monitoring of variables that are not used in a control loop, sequence logic, or safety, such as status of sump pumps or	X	X	X

Application Category	Examples	Acceptable Controller		
		ASC	AAC	BC
	associated float switches, temperatures in monitored electrical rooms.			
1	Miscellaneous heaters Constant speed exhaust fans and pumps	X	X	X
2	VAV Boxes	X		
3	HW/CHW Plant connections	X (note 1)	X	X
4	Heating Air Handling System		X (note 1)	X
5	Cooling Air Handling System			X
Notes: Controller may be used only if all control functions and physical I/O associated with a given unit resides in one AAC/ASC				

2. ASC Installation
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
   b. ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
3. AAC and BC Installation
   a. AACs/BCs shall be located in a temperature control cabinets constructed per Paragraph 2.8.

3.7 COMMUNICATION DEVICES

A. General
   1. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details indicated on Drawings.
   2. Provide all interface devices and software to provide an integrated system.

B. LANID and LAN Routers
   1. Provide as required
   2. Connect networks to both sides of device
   3. Thoroughly test to ensure proper operation
   4. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.

C. Gateways and Routers to Equipment Controllers
   1. See Paragraph 2.4C for network connection of gateways and routers.
   2. Wire to networks on both sides of device.
   3. Map across all monitoring and control points listed in Paragraph 2.12C.

4. Thoroughly test each point to ensure that mapping is accurate.
5. Initiate trends of points as indication in Paragraph 2.12C.

D. External Communications
1. Provide an Ethernet second port on the CSS to which the Owner can connect their Owner IT LAN (intranet), by others. Contractor shall coordinate with the Owner's Representative to establish an IP address and communications parameters to assure proper operation. This connection shall also provide access to Internet through Owner's firewall to Internet Services Provider procured by Owner.

3.8 CONTROL AIR TUBING

A. Sensor air tubing shall be sized by the Contractor.

B. All control air piping shall be concealed except in equipment rooms or unfinished areas.

C. Installation methods and materials
1. Concealed and Inaccessible: Use copper tubing or FR plastic in metal raceway. Exception: Room thermostat drops in stud walls in areas with lay-in ceiling may be FR plastic tubing.
2. Concealed and Accessible tubing (including ceiling return air plenums) shall be copper tubing or FR plastic tubing, subject to the following limitations
   a. FR tubing shall be enclosed in metal raceway when required by local code.
   b. Quantity of FR tubing per cubic foot of plenum space shall not exceed manufacturer's published data for Class 1 installation.
3. Exposed to view or damage: Use hard-drawn copper or FR plastic in metal raceway.
   a. Where copper tubing is used, a section 12 inches or less of FR plastic tubing is acceptable at final connection to control device.

D. Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum 1 inch sleeves, extended 6 inches above floors and 1 inch below bottom surface of slabs.

E. Pneumatic tubing shall not be run in raceway containing electrical wiring.

F. Where FR tubing exits the end of raceway or junction box, provide a snap-in nylon bushing. Where pneumatic tubing exits control panels, provide bulkhead fittings. Where copper tubing exits junction boxes or panels, provide bulkhead fittings.

G. All tubing shall be number coded on each end and at each junction for easy identification.

H. All control air piping shall be installed in a neat and workmanlike manner parallel to building lines with adequate support.

I. Piping above suspended ceilings shall be supported from or anchored to structural members or other piping or duct supports. Tubing shall not be supported by or anchored to electrical raceways or ceiling support systems.

J. Brass-barbed fittings shall be used at copper-to-FR tubing junctions. Plastic slipped-over copper tubing is not acceptable.

K. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

3.9 CONTROL POWER

A. Power wiring and wiring connections required for Work in this Section shall be provided under this Section unless specifically indicated on Division 26 Drawings or Specifications. See Paragraph 1.1B.

B. Extend power to all BAS devices, including 120V power to panels, from an acceptable power panel.
   1. See Division 26 Electrical Drawings for power locations pre-allocated for BAS system.
   2. Where no power source is indicated on drawings, for bid purposes only, assume a dedicated circuit is available within an average of 20 feet of panel location. If this is not the case, request additional cost prior to submission of shop drawings or no additional costs will be reimbursed.
   3. Coordinate with Division 26 during shop drawing development for final connection location.

C. General requirements for obtaining power include the following:
   1. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it.
   2. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120V source fed from a common origin.
   3. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment's control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the equipment's control transformer is not large enough or not of the correct voltage to supply the controls, provide separate transformer(s).
   4. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, or interruptible), the controller shall be powered by the highest level of reliability served.

D. Unless transformers are provided with equipment as specified in related Division 23 and 26 equipment Sections, Contractor shall provide transformers for all low voltage control devices including non-powered terminal units such as cooling-only VAV boxes and VAV boxes with hot water reheat. Transformer(s) shall be located in control panels in readily accessible locations such as Electrical Rooms.

E. Power line filtering. Provide transient voltage and surge suppression for all workstations and BCs either internally or as an external component.

3.10 CONTROL AND COMMUNICATION WIRING

A. Control and Signal Wiring
   1. Comply with Division 26.
   2. Line Voltage Wiring
      a. All line-voltage wiring shall meet NEC Class 1 requirements.

b. All Class 1 wiring shall be installed in UL Listed approved raceway per NEC requirements and shall be installed by a licensed electrician.
c. Class 1 wiring shall not be installed in raceway containing pneumatic tubing.

3. Low Voltage Wiring
   a. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
   b. Class 2 wiring shall be installed in UL Listed approved raceway as follows:
      1) Where located in unconcealed or inaccessible locations, such as:
         a) Equipment rooms
         b) Exposed to weather
         c) Exposed to occupant view
         d) Inaccessible locations such as concealed shafts and above inaccessible ceilings
      2) Class 2 wiring shall not be installed in raceway containing Class 1 wiring.
   c. Class 2 wiring need not be installed in raceway as follows:
      1) Where located in concealed and easily accessible locations, such as:
         a) Inside mechanical equipment enclosures and control panels
         b) Above suspended accessible ceilings (e.g. lay-in and spline)
         c) Above suspended drywall ceilings within reach of access panels throughout
         d) In shafts within reach of access panels throughout
         e) Nonrated wall cavities
      2) Wiring shall be UL Listed for the intended application. For example, cables used in floor or ceiling plenums used for air transport shall be UL Listed specifically for that purpose.
      3) Wiring shall be supported from or anchored to structural members neatly tied at 10 foot intervals and at least 1 foot above ceiling tiles and light fixtures. Support or anchoring from straps or rods that support ductwork or piping is also acceptable. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceilings.
      4) Install wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
   d. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two (for example relays and transformers).

4. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
5. All field wiring shall be properly labeled at each end, with self-laminating typed labels indicating device address, for easy reference to the identification schematic. All power wiring shall be neatly labeled to indicate service, voltage, and breaker source.
6. Use coded conductors throughout with different colored conductors.
7. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
8. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Contractor shall provide step-down transformers.
9. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
10. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendation and NEC requirements.
11. Include one pull string in each raceway 1 inch or larger.
12. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

13. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (for example steam pipes or flues).
14. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
15. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
16. Terminate all control or interlock wiring.
17. Maintain updated as-built wiring diagrams with terminations identified at the jobsite.
18. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inches electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.
19. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings per code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.
20. Wire digital outputs to either the normally-closed or normally-open contacts of binary output depending on desired action in case of system failure. Unless otherwise indicated herein, wire to the NO contact except the following shall be wired to the NC contact
    a. Hot water pumps
21. Hardwire Interlocks
    a. The devices referenced in this Section are hardwire interlocked to ensure equipment shutdown occurs even if control systems are down. Do not use software (alone) for these interlocks.
    b. Hardwire device NC contact to air handler fan starter upstream of HOA switch, or to VFD enable contact.
    c. Where multiple fans (or BAS DI) are controlled off of one device and the device does not have sufficient contacts, provide a relay at the device to provide the required number of contacts.
    d. Provide for the following devices where indicated on Drawings or in Sequences of Operation:
        1) Duct smoke detector
        2) High discharge static pressure
        3) Low mixing plenum pressure
22. Shielded cable shield shall be grounded only at one end. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

B. Communication Wiring
1. Adhere to the requirements of Paragraph 3.10A in addition to this Paragraph.
2. Communication and signal wiring may be run without conduit in concealed, accessible locations as permitted by Paragraph 3.10A only if noise immunity is ensured. Contractor is fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
3. All cabling shall be installed in a neat and workmanlike manner. Follow all manufacturers' installation recommendations for all communication cabling.
4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
5. Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.
6. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

7. All runs of communication wiring shall be unspliced length when that length is commercially available.
8. All communication wiring shall be labeled to indicate origination and destination data.
9. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communications Circuits, Cable and Protector Grounding.
10. Power-line carrier signal communication or transmission is not acceptable.

3.11 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Sensors used as controlled points in control loops shall be hardwired to the controller to which the controlled device is wired and in which the control loop shall reside.

D. Temperature Sensors
1. Room temperature sensors and thermostats shall be installed with back plate firmly secured to the wall framing or drywall anchors.
   a. For sensors mounted in exterior walls or columns, use a back plate insulated with foam and seal all junction box openings with mastic sealant.
   b. For sensors on exposed columns, use Wiremold or equal enclosures that are the smallest required to enclose wiring (e.g. Wiremold 400 BAC or equal) and Wiremold or equal junction boxes that are the narrowest required to enclose the temperature sensor and wiring connections (e.g. Wiremold 2348S/51 or equal). Color or raceway and boxes shall be per the architect; submit for approval prior to installation.
2. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
3. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip. Where located in front of filters (such as mixed air sensors), access for filter removal shall be maintained.
4. Temperature sensors downstream of coils shall be located as far from the coil fins as possible, 6 inches minimum. Temperature sensors upstream of coils shall be a minimum of 6 inches away from the coil fins. No part of the sensor or its support elements or conduit shall be in contact with the coil, coil framing or coil support elements. Discharge temperature sensors on VAV boxes shall be mounted as far from the coil as possible but upstream of the first diffuser with the probe located as near as possible to the center of the duct both vertically and horizontally.
5. All pipe-mounted temperature sensors shall be installed in wells. For small piping, well shall be installed in an elbow into pipe length. Install the sensor in the well with a thermal-conducting grease or mastic. Use a closed-cell insulation patch that is integrated into the pipe insulation system to isolate the top of the well from ambient conditions but allow easy access to the sensor. Install a test plug adjacent to all wells for testing and calibration.
6. Unless otherwise noted on Drawings or Points List, temperature sensors/thermostats, humidity sensors/humidistats, CO_2 sensors, and other room wall mounted sensors shall be installed at same centerline elevation as adjacent electrical switches, 4 feet above the finished floor where there are no adjacent electrical switches, and within ADA limitations.
7. Unless otherwise noted on Drawings or Points List, install outdoor air temperature sensors on north wall where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

E. Differential Pressure Sensors

1. Supply Duct Static Pressure
    a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
    b. Low pressure port of the pressure sensor
        1) Pipe to either
            a) Building pressure (high) signal of the building static pressure transmitter.
            b) Open to a conditioned space inside the building
            c) Open to the BAS panel in which the DPT is mounted provided the panel is inside the building envelope and not in an air plenum.
    c. High-pressure port of the pressure sensor
        1) Pipe to the duct using a static pressure tip located as indicated on Drawings; if no location is indicated, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers.
        2) Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions.
2. Building Static Pressure
    a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
    b. Low pressure port of the pressure sensor
        1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.
    c. High-pressure port of the pressure sensor
        1) Pipe to either
            a) Behind a BAS temperature sensor cover in an interior zone (provided sensor has openings to allow ambient air to freely flow through it)
            b) Wall plate sensor
        2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.
3. Filter Differential Pressure
    a. Install static-pressure tips upstream and downstream of filters with tips oriented in direction of flow. If there is a Magnehelic gauge installed by the AHU manufacturer, it may be removed and discarded with its pressure tips used for the DPT provided the DPT has an LCD so it can double as a visual gauge.
    b. Mount transmitter on outside of filter housing or filter plenum in an accessible position with LCD display clearly visible. This sensor is used in lieu of an analog gauge and thus must be readily viewable.
4. High/Low Static Pressure Safeties
    a. High static
        1) Install DPS-2 on side of supply air duct in accessible location.
        2) High port shall be open to supply air duct downstream of fan.
        3) Reference low port pressure shall be that at DP location.
    b. Low static
        1) Install DPS-2 inside or outside of mixed air plenum whichever is most accessible.
        2) Low port shall be open to mixed air plenum.
        3) Reference high port pressure shall be pressure on other side of mixed air plenum with the highest pressure, e.g. ambient pressure for systems with relief fans or non-powered relief, or relief air plenum for systems with return fans.
5. All pressure transducers, other than those controlling VAV boxes, shall be located where accessible for service without use of ladders or special equipment. If required, locate in field device panels and pipe to the equipment monitored or ductwork.
6. The piping to the pressure ports on all pressure transducers (both air and water) shall contain a capped test port located adjacent to the transducer.
7. Piping differential pressure transducers shall have one of the following:

a. Five valve manifold, brass, two valves to allow removal of sensor without disrupting the hydronic system, an equalizing valve to allow the sensor to be zeroed and to prevent sensor from experiencing full static (as opposed to differential) where, and two valves used as air vents that also can be used as test plugs for calibration.
b. For sensors using two separate sensors, install test plugs on each connection for calibration and also used as vents.

F. Current Switches and Current Transformers for Motor Status Monitoring
1. For CTs, create a software binary point for fan status triggered at a setpoint determined below and ~10% deadband.
2. Adjust the setpoint so that it is below minimum operating current and above motor no load current. For fans with motorized discharge dampers, adjust so that fan indicates off if damper is closed while fan is running. For pumps, adjust so that pump indicates off if valve is closed while pump is running.

G. Airflow Measuring Stations: Install per manufacturer's recommendations for unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

H. Fluid Flow Meters: Install per manufacturer's recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. Commission per the manufacturer's startup and commissioning recommendations. Complete all manufacturer's startup documentation and include this in prefunctional commissioning report.

I. Actuators
1. Type: All actuators shall be electric.
2. Mount and link control damper actuators per manufacturer's instructions.
3. Dampers
a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage, or follow manufacturer's instructions to achieve same effect.
b. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
c. Provide all mounting hardware and linkages for actuator installation.
4. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, mount the valve so that the position indicator is visible from the floor or other readily accessible location. However, do not install valves with stem below horizontal or down. The preferred location for the valve and actuator is on lowest point in the valve train assembly for ease of access and inspection. If this is on the coil supply piping, the control valve may be located there even if schematics (and standard practice) show valves located on the coil return piping. This comment applies to both 2−way valves and 3-way valves (which would become diverting valves rather than mixing valves in this location).

3.12 SOFTWARE INSTALLATION

A. System Configuration
1. Thoroughly and completely configure BAS system software, supplemental software, network software etc. on OWS, POTs, and servers.

B. Point Structuring and Naming
   1. The intent of this Paragraph is to require a consistent means of naming points across the BAS. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.
   2. Point Summary Table
      a. The term “Point” includes all physical I/O points, virtual points, and all application program parameters.
      b. With each schematic, provide a Point Summary Table listing
         1) Building number and abbreviation
         2) System type
         3) Equipment type
         4) Point suffix
         5) Full point name (see Point Naming Convention Paragraph)
         6) Point description
         7) Ethernet backbone network number
         8) Network number
         9) Device ID
         10) Device MAC address
         11) Object ID (object type, instance number)
         12) Engineering units
         13) Device make and model number; include range of device if model number does not so identify.
         14) Device physical location description; include floor and column line intersection to one decimal place (for example line 6.2 and line A.3).
      c. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).
      d. Coordinate with the Owner’s representative and compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup.
      e. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.
   3. Point Naming Convention
      a. All point names shall adhere to the format as established below, unless otherwise agreed to by the Owner. New categories and descriptors may be created with approval of the Owner.
      b. Format:
         1) Building.Category.System.EquipmentTag.Component.Property.
         2) Example: 001.HVAC.Heatplant.B-1.HWS.Temperature

Building	Category	System	Equipment Tag	Component	Property	Typical units
Building number	ELCT	Lighting Plug Generator Misc	(from equipment schedules)	SWITCH PHOTO CB	Command Status Light Power	On/off On/off Footcandles Watts
	HVAC	Airhandling Exhaust Heatplant Coolplant Misc		CWS CWR HWS HWR CHWS	Voltage Current ValvePos DamperPos Temperature	Volts Amps %open %open °F

Building	Category	System	Equipment Tag	Component	Property	Typical units
	PLMB	Domwater Air Natgas N2 O2 Irrigation Waste Misc		CHWR OA SA RA EA GAS FLUID	Humidity Pressure Flow Energy Speed Signal	%RH Psig, "H_2O Cfm, gpm Btu %, Hz %
	MISC	Weather				

4. Device Addressing Convention
   a. BACnet network numbers and Device Object IDs shall be unique throughout the network.
   b. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner to ensure there are no duplicate BACnet device instance numbers.
   c. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner: VVVNN, where: VVV = 0-999 for BACnet Vendor ID, NN = 00 - 99 for building network.
   d. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner: VVVNNDD , where: VVV = number 0 to 999 for BACnet Vendor ID , NN = 00 - 99 for building network, DD = 01-99 for device address on a network.
   e. Coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
   f. Alternative Device ID schemes or cross-project Device ID duplication if allowed shall be approved before Project commencement by the Owner.
5. I/O Point Physical Description
   a. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:
      1) The device manufacturer and model number. Include range of device if model number does not so identify.
      2) For space sensors, include room number in which sensor is located.

C. Point Parameters
1. Provide the following minimum programming for each analog input
   a. Name
   b. Address
   c. Scanning frequency or COV threshold
   d. Engineering units
   e. Offset calibration and scaling factor for engineering units
   f. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
   g. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides or failure of any network over which the point value is transferred.
2. Provide the following minimum programming for each analog output
   a. Name
   b. Address
   c. Engineering units

d. Offset calibration and scaling factor for engineering units
e. Output Range
f. Default value to be used when the normal controlling value is not reporting.

3. Provide the following minimum programming for each digital input
   a. Name
   b. Address
   c. Engineering units (on/off, open/closed, freeze/normal, etc.)
   d. Debounce time delay
   e. Message and alarm reporting as specified
   f. Reporting of each change of state, and memory storage of the time of the last change of state
   g. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
4. Provide the following minimum programming for each digital output
   a. Name
   b. Address
   c. Output updating frequency
   d. Engineering units (on/off, open/closed, freeze/normal, etc.)
   e. Direct or Reverse action selection
   f. Minimum on-time
   g. Minimum off-time
   h. Status association with a DI and failure alarming (as applicable)
   i. Reporting of each change of state, and memory storage of the time of the last change of state.
   j. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
   k. Default value to be used when the normal controlling value is not reporting.

D. Site-Specific Application Programming
1. All site specific application programming shall be written in a manner that will ensure programming quality and uniformity. Contractor shall ensure:
   a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
   b. Programs for like functions are identical, to reduce debugging time and to ease maintainability.
   c. Programs are thoroughly debugged before they are installed in the field.
2. Massage and tune application programming for a fully functioning system. It is the Contractor's responsibility to request clarification on sequences of operation that require such clarification.
3. All site-specific programming shall be fully documented and submitted for review and approval
   a. Prior to downloading into the panel (see Submittal Package 2, Paragraph 1.6.)
   b. At the completion of functional performance testing, and
   c. At the end of the warranty period (see Warranty Maintenance, Paragraph 1.11).
4. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the Project will be the property of the Owner and shall remain on the workstations/servers at the completion of the Project.

E. Graphic Screens
1. All site specific graphics shall be developed in a manner that will ensure graphic display quality and uniformity among the various systems.
2. Schematics of MEP systems

a. Schematics shall be 2-D or 3-D and shall be based substantially on the schematics provided on Drawings.
b. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.
c. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.
d. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

3. Displays shall show all points relevant to the operation of the system, including setpoints.
4. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.
5. Show weather conditions (local building outside air temperature and humidity) in the upper left hand corner of every graphic.
6. CAD Files: The contract document drawings will be made available to the Contractor in AutoCAD format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However the Owner does not guarantee the suitability of these drawings for the Contractor's purpose.
7. Provide graphics for the following as a minimum
   a. Site homepage: Background shall be a campus map, approximately to scale. Include links to each building, central plant, etc.
   b. Building homepage: Background shall be a building footprint, approximately to scale, oriented as shown on the campus homepage. Include links to each floor and mechanical room/area, and to summary graphics described below. Include real-time site utility data such as building electrical demand and domestic cold water flow demand shown roughly on the map where the utilities connect to the site.
   c. Electricity demand limiting
      1) Demand limit. Include entries for sliding window interval and a table of Off-Peak, On-Peak or Partial-Peak demand time periods, both Summer and non-Summer, with three adjustable demand level limits for each and adjustable deadband.
      2) Electricity demand calculation. For each month, show actual peak kW and kWh for each time-of-day rate period. Show side-by-side as month-this-year and month-last-year, and month-to-date and year-to-date data.
   d. Each occupied floor plan, to scale
      1) HVAC: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone's actual comfort condition changes. In each zone, provide links to associated terminal equipment.
      2) If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.
   e. Each equipment floor/area plan: To scale, with links to graphics of all BAS controlled/monitored equipment.
   f. Each air handler and fan-coil: Provide link to associated HW and CHW plants where applicable.

g. Each trim & respond reset: Next to the display of the setpoint that is being reset, include a link to page showing all trim & respond points (see Guideline 36) plus the current number of requests, current setpoint, and status indicator point with values “trimming,” “responding,” or “holding.” Include a graph of the setpoint trend for the last 24 hours. Trim & respond points shall be adjustable from the graphic except for the associated device.
h. Each zone terminal:
    1) Provide link to associated air handling unit where applicable and to floor plan where terminal is located.
    2) Include supply air temperature from AHU serving terminal unit.
    3) Include a non-editable graphic (picture) showing the design airflow setpoints from the design drawings adjacent to the editable airflows setpoints. The intent is that the original setpoints be retained over time despite “temporary” adjustments that may be made over the years.
i. Electrical power monitoring system: Show a schematic of the electrical system based on one-line diagrams with meter current kW reading and month-to-date kWh shown in actual locations. Power flow shall change on the diagram (by changing line color or width) to show which power line is active.
j. Central plant equipment including chilled water system, cooling tower system, hot water system, steam system, generators, etc.: The flow path shall change on the diagram (by changing piping line color or width) to show which piping has active flow into each boiler, chiller, tower, etc. as valve positions change.
k. Summary graphics: Provide a single text-based page (or as few as possible) for each of the following summary screens showing key variables listed in columns for all listed equipment. Include hyperlinks to each zone imbedded in the zone tag:
    1) Air handling units: operating mode; on/off status; supply air temperature; supply air temperature setpoint; fan speed; duct static pressure; duct static pressure setpoint; outdoor air and return air damper position; coil valve positions; etc. (all key operating variables); Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (if HW coil)
    2) VAV Zone terminal units: operating mode; airflow rate; airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; damper position; HW valve position (reheat boxes); supply air temperature (reheat boxes); supply air temperature setpoint (reheat boxes); CO2 concentration and CO2 loop output (where applicable); Fan start/stop command, speed, and status (fan-powered); Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier (dual duct); Heating SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier (dual duct).
    3) Electrical meters and switches: Volts, current, kW, switch positions.
l. For all equipment with runtime alarms specified, show on graphic adjacent to equipment the current runtime, alarm setpoint (adjustable), alarm light, date of last runtime counter reset, and alarm reset/acknowledge button which resets the runtime counter.
m. For all equipment with lead/lag or lead/standby operation specified, show on graphic adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual lead switching by the operator per Paragraph 3.13B.5.
n. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.
o. All other BAS controlled/monitored equipment.

p. On all system graphics, include a “note” block that allows users to enter comments relevant to system operation.
q. All equipment shall be identified on the graphic screen by the unit tag as scheduled on the drawings.

F. Alarm Configuration
1. Program alarms and alarm levels per Sequence of Operations.
2. Each programmed alarm shall appear on the alarm log screen and shall be resettable or acknowledged from those screens. Equipment failure alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, fan alarm shall be shown on graphic air handling system schematic screen). For all graphic screens, display values that are in a Level 1 or 2 condition in a red color, Level 3 and higher alarm condition in a blue color, and normal (no alarm) condition in a neutral color (black or white).
3. For initial setup, Contractor shall configure alarms as follows:

	Level 1	**Level 2**	**Level 3**	**Level 4**
Criticality	Critical	Not Critical	Not Critical	Not Critical
Acknowledgement	Required	Required	Not Required	Not Required
Acknowledgement of Return to Normal	Not Required	Not Required	Not Required	Not Required
Email to building engineer(s)	Y	Y	Y	N
SMS text to building engineer(s)	Y	Y	N	N
Pop-up dialog box on OWS	Y	Y	N	N
Remove from alarm log	After Acknowledged	After Acknowledged	After 2 weeks	After 2 weeks

3.13 SEQUENCES OF OPERATION

A. Sequences herein reference ASHRAE Guideline 36-2018 including published addenda, possibly followed by exceptions or additions where indicated. Guideline 36 sequences are not repeated herein for brevity and to make exceptions/revisions very clear. However, the final as-built sequences of operation (see Paragraph 1.7B.1.j and 2.11C.1.d.3)a)1) shall include all installed sequences verbatim from Guideline 36.

B. General
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.1 General.
2. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Proposed changes in sequences shall be included as a part of Submittal Package 2.
3. Include costs for minor program modifications if required to provide proper performance of the system.
4. Minimum speed setpoints for all VFD-driven equipment shall be determined in accordance with Paragraph 3.14D.8.
5. Equipment Staging and Rotation
a. Parallel devices shall be lead/lag or lead/standby rotated to maintain even wear.
b. Two runtime points shall be defined for each device:
1) Lifetime Runtime: The cumulative runtime of the device since device start-up. This point shall not be readily resettable by operators.

2) Staging Runtime: An operator resettable runtime point that stores cumulative runtime since the last operator reset.

c. Lead/lag devices: Unless otherwise noted, parallel staged devices (such as CHW pumps and cooling towers) shall be lead/lag alternated when more than one is off or more than one is on so that the device with the most operating hours as determined by Staging Runtime is made the last stage device and the one with the least number of hours is made the lead stage device.

d. Exceptions to Lead/lag rotation

1) Operators with appropriate access level shall be able to manually command staging order via software points, but not overriding the In Alarm or Hand Operation logic below.

a) Faulted Devices: A faulted device is any device commanded to run that is either not running or unable to perform its required duty. If an operating device has any fault condition described subsequently, a Level 2 alarm shall be generated and a response shall be triggered as defined below.

1. Fans and Pumps

a. Status point not matching its on/off point for 15 seconds after a time delay of 15 seconds when device is commanded on.

b) Upon identification of a fault condition:

1. For fans and pumps:

a. The next commanded OFF device in the staging order, Device “B”, shall be commanded ON while alarming Device “A” remains commanded ON.

b. If Device B fails to prove status (i.e. it also goes into alarm), it shall remain commanded on and the preceding step shall be repeated until the quantity of devices called for by the lead/lag logic have proven on.

c. When either the required number of devices proves on or all devices are commanded on, set alarming devices to the last positions in the lead/lag staging order sequenced reverse chronologically (i.e. the device that alarmed most recently is sent to last position).

d. Staging order of non-alarming devices shall follow the even wear logic. A device in alarm can only automatically move up in the staging order if another device goes into alarm.

e. Devices in alarm shall run if so called for by the lead/lag staging order and present stage.

2) Hand Operation: If a device is on in Hand (e.g., via an HOA switch or local control of VFD), the device shall be set to the lead device and a Level 4 alarm shall be generated. The device will remain as lead until the alarm is reset by the operator. Hand operation is determined by:

a) Fans and Pumps

1. Status point not matching its on/off point for 15 seconds after a time delay of 60 seconds when device is commanded off.

6. Occupancy Status

a. Occupancy status of all spaces shall be via the Lighting Control BACnet interface.

b. Where a zone serves more than one room, “unoccupied” (or “unpopulated” per Guideline 36 terminology) means all rooms are unoccupied and “occupied” (populated) means any room is occupied.

c. In case of the network connection with the Lighting Controls is lost, occupancy status shall default to “occupied” if the Zone Group is in Occupied Mode and “unoccupied” for any other Zone Group Mode.

7. VAV Box Controllable Minimum

a. This section is used to determine the lowest possible VAV box airflow setpoint (other than zero) allowed by the controls (*Vm*) used in VAV box control sequences. The minimums shall be stored as software points that may be adjusted by the user but need not be adjustable via the graphical user interface.
b. Option 1: If the VAV box controller can control to 0.004" per Paragraph 2.9H.5.c., the minimum setpoint *Vm* shall be determined from the table below if the VAV box manufacturer is listed:

Inlet	Titus	Krueger	Price	MetalAire High Gain	ETI
4	15	15	20	15	15
6	30	35	30	30	30
8	55	60	55	50	55
10	90	90	95	85	90
12	120	130	135	110	130
14	190	175	195	155	180
16	245	230	260	210	235
24x16	455	445	490	N/A	415

c. Option 2: The minimum setpoint *Vm* shall be determined per Guideline 36.

C. Electricity Demand Limiting
1. Sliding Window: The demand control function shall utilize a sliding window method selectable in increments of one minute, up to 60 minutes, 15 minute default.
2. Demand Levels: Demand time periods shall be set up as per utility rate schedule. For each On/Off/Partial-Peak period, three demand level limits can be defined. When the measured demand exceeds the limit, the Demand Limit Level switch for that level shall be set; when demand is more than 10% (adjustable) below the limit for a minimum of 15 minutes, or the time is no longer within the On/Off/Partial-Peak window, the switch shall be reset. These levels are used at the zone level (see Zone Control sequences) to shed demand.
3. In addition to setpoint reset logic triggered by Demand Levels as described below, include Demand Shed commands to the lighting control system via BACnet interface for each Demand Level. The response to each Demand Shed command shall be programmed into the lighting control system under Division 26.

D. Zones
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.2 Generic Ventilation Zones.
   a. Use Title 24 for ventilation logic.
      1) Add the following to 5.2.1.4.2
         a) c. If no value or if "AUTO" is entered in VAV box schedules for Occupied Minimum Airflow Setpoint (Vmin), Vmin shall be set equal Zone-Abs-OA-min
   b. Fully implement Time Averaged Ventilation (TAV) 5.2.2 and use it when VAV minimum, Vmin*, is below the lowest allowed by the controls (*Vm*).
2. Fully comply with ASHRAE Guideline 36-2018 Section 5.3 Generic Thermal Zones.
   a. Default setpoints:

Zone type	Occupied		Unoccupied	
	Heat	Cool	Heat	Cool
VAV exterior	70ºF	75ºF	60ºF	90ºF
VAV interior	70ºF	73ºF	60ºF	90ºF
Electrical and mechanical	60ºF	85ºF	60ºF	85ºF
IDF/MDF	60ºF	78ºF	60ºF	78ºF

E. Zone Groups
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.4 Zone Groups.
2. Unless otherwise specified by Owner, the following Zone Groups shall be created:

Zone Group Name	AH Tag	Terminal Unit Tags	Default Schedule
1st Floor	AH-C/H	VAV-1-x	WD: 6am to 8pm WE: 8am to 10pm HOL: off
2nd Floor	AH-C/H	VAV-2-x	WD: 6am to 8pm WE: 8am to 10pm HOL: off
3rd Floor	AH-C/H	VAV-2-x	WD: 6am to 8pm WE: 8am to 10pm HOL: off

F. VAV Cooling-only boxes
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.5 unless otherwise noted below.
2. Parameters
   a. Design Information (see VAV Box schedule):
      1) Vcool-max, zone maximum cooling airflow setpoint
      2) Vmin, zone occupied minimum airflow setpoint (optional; If Vmin airflow setpoint is not entered in schedules, Vmin will be dynamically calculated using Paragraph 3.13D.1.a.1).)
      3) Vocc-min, zone minimum outdoor airflow for occupants, per Title 24 prescribed airflow-per-occupant requirements
      4) Varea-min, zone minimum outdoor airflow for building area, per Title 24 prescribed airflow-per-area requirements

G. Dual Duct VAV Boxes – Snap Acting Control
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.11. unless otherwise noted below.
2. Parameters
   a. Design Information (see VAV Box schedule):
      1) Vcool-max, zone maximum cooling airflow setpoint
      2) Vmin, zone occupied minimum airflow setpoint (optional; If Vmin airflow setpoint is not entered in schedules, Vmin will be dynamically calculated using Paragraph 3.13D.1.a.1).)
      3) Vheat-max, zone maximum heating airflow setpoint
      4) Vocc-min, zone minimum outdoor airflow for occupants, per Title 24 prescribed airflow-per-occupant requirements
      5) Varea-min, zone minimum outdoor airflow for building area, per Title 24 prescribed airflow-per-area requirements

H. Dual Duct VAV Terminal Unit – Mixing Control with Inlet Airflow Sensors
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.12. unless otherwise noted below.
2. Parameters
   a. Design Information (see VAV Box schedule):
      1) Vcool-max, zone maximum cooling airflow setpoint
      2) Vmin, zone occupied minimum airflow setpoint (optional; If Vmin airflow setpoint is not entered in schedules, Vmin will be dynamically calculated using Paragraph 3.13D.1.a.1).)
      3) Vheat-max, zone maximum heating airflow setpoint

4) Vocc-min, zone minimum outdoor airflow for occupants, per Title 24 prescribed airflow-per-occupant requirements
5) Varea-min, zone minimum outdoor airflow for building area, per Title 24 prescribed airflow-per-area requirements

I. VAV Cooling-only boxes to Thermafuser
1. Design airflow rates shall be as scheduled on plans:
   a. Zone maximum cooling airflow setpoint (Vcool-max)
   b. Zone occupant component of minimum outdoor air setpoint (Vocc-min)
   c. Zone building area component of minimum outdoor air setpoint (Varea-min)
   d. If occupied standby is allowed
2. Zone minimum outdoor air setpoints (used at AHU level minimum outdoor air controls)
   a. Zone-Abs-OA-min is equal to
      1) Varea-min if the zone has a CO_2 sensor
      2) Varea-min if the zone has an occupancy sensor and the zone is unoccupied
      3) Zone-Des-OA-min otherwise.
   b. Zone-Des-OA-min is equal to the larger of Varea-min and Vocc-min.
3. Zone minimum airflow setpoint (Vmin*) set to zero
4. DP setpoint set by TAB contractor; default = 0.2”
5. Active maximum and minimum setpoints shall vary depending on the mode of the Zone Group the zone is a part of:

Setpoint	Occupied	Cool-down	Setup	Warm-up	Setback	Unoccupied
Cooling maximum	Vcool-max	Vcool-max	Vcool-max	0	0	0
Minimum	0	0	0	0	0	0

6. Control logic
   a. When zone is in Occupied, Cool-down, or Setup modes, modulate damper to maintain DP at DP setpoint. Loop is disabled and damper is closed otherwise.
   a. A P-only loop whose output is maximum damper position shall limit airflow to Vcool-max.
   b. If the zone has an occupancy sensor, is unoccupied, and occupied-standby mode is permitted, the loop is disabled and the VAV damper shall close.
7. Alarms
   a. Airflow sensor calibration. If the fan serving the zone has been shut off for 10 minutes and the absolute airflow sensor reading is greater than 20 cfm, generate a Level 3 alarm.
8. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to
   a. Force zone airflow setpoint to zero
   b. Force zone airflow setpoint to Vcool-max.
   c. Force damper full closed/open
   d. Reset request-hours accumulator point to zero (provide one point for each reset type listed below)
9. System Requests
   a. Cooling SAT Reset Requests
      1) Not used
   b. Static Pressure Reset Requests
      1) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 Requests,
      2) Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 Requests,

3) Else if the damper position is greater than 95%, send 1 Request until the damper position is less than 85%,
4) Else if the damper position is less than 95%, send 0 Requests

J. Air Handling Unit System Modes:
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.15 unless otherwise noted.

K. Cooling VAV Air Handler
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.16 unless otherwise noted.
2. Parameters
a. Design Information:
1) Temperature Setpoints
a) Min_ClgSAT, lowest cooling supply air temperature setpoint: 55°F.
b) Max_ClgSAT, highest cooling supply air temperature setpoint: 65°F.
c) OAT_Min, the lower value of the OAT reset range: 50°F.
d) OAT_Max, the higher value of the OAT reset range: 70°F.
2) Ventilation Setpoints
a) AbsMinOA: the design outdoor airflow rate when all zones with CO2 sensors or occupancy sensors are unpopulated: per AHU schedule
b) DesMinOA: the design minimum outdoor airflow with areas served by the system are occupied at their design population: per AHU schedule
3) Economizer High Limit: Paragraph 3.1.4.3.2 (California Title 24 economizer high limit requirements)
a) California Climate Zone: 3
b) High limit option: Fixed Dry Bulb + Differential Dry Bulb
b. TAB Information
1) Duct design maximum static pressure, Max_DSP to be determined by Section 230593 Testing, Adjusting and Balancing.
2) Minimum Fan Speed: Per Paragraph 3.14D.8
3. Use the following options/revisions:
a. Supply fan control: Section 5.16.1 modified as follows:
1) Staged supply fan controls
a) VFD Fan groups shall be lead/lag controlled per Paragraph 3.13B.5.
b) When fans are enabled, start the lead supply fan. When %-supply airflow (totalized enabled VAV box readings divided by design AHU airflow) exceeds stage-up setpoint (below) for 15 minutes (adjustable) then the next lag supply fan shall run. All VFDs receive the same speed signal. When %-airflow falls below the stage-up setpoint for 15 (adjustable) minutes then last lag fan shall be staged off.

VFD Stage	Stage up Flow
1	0%
2	45%

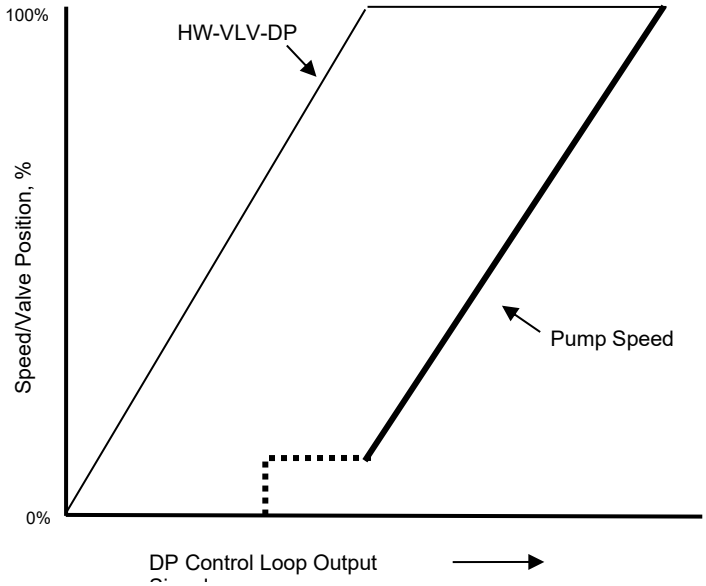
b. Supply Air Temperature Control:
1) Per Figure 5.16.2.3-1, except:
a) When switching from Heating Mode to Cooling Mode and vice versa, wait the longer of the nominal timing of the changeover valve and 5 minutes (adj.) since the 2-way control valve was last shut prior to releasing the control valve to open (the intent of this logic is twofold: to avoid sending chilled water into the hot water system before the changeover valve is fully indexed, and to give the fluid trapped in the coil time to reach neutral temperature before being passed to the other loop).
b) Control valve output action shall be direct-acting when in Cooling Mode and reverse acting when in heating mode.
c. Minimum outdoor air setpoint and control: per Title 24

d. Minimum Outdoor Air Control: Option per AHU design; see control schematics.
e. Relief Fan Control. Section 5.16.9 modified as follows:
1) Relief fans or VFD Fan groups shall be lead/lag controlled per Paragraph 3.13B.5.

L. Heating VAV Air Handler
1. Fully comply with ASHRAE Guideline 36-2018 Section 5.17 unless otherwise noted.
2. Parameters
a. Design Information:
1) Temperature Setpoints
a) Max_HtgSAT, highest heating supply air temperature = 95°F
b. TAB Information
1) Duct design maximum static pressure, Max_DSP to be determined under Section 230593 Testing, Adjusting and Balancing.
2) Minimum Fan Speed: Per Paragraph 3.14D.8
3. Use the following options/revisions:
a. Supply fan control: Section 5.17.1 modified as follows:
1) Staged supply fan controls
a) VFD Fan groups shall be lead/lag controlled per Paragraph 3.13B.5.
b) When fans are enabled, start the lead supply fan. When %-supply airflow (totalized enabled VAV box readings divided by design AHU airflow) exceeds stage-up setpoint (below) for 15 minutes (adjustable) then the next lag supply fan shall run. All VFDs receive the same speed signal. When %-airflow falls below the stage-up setpoint for 15 (adjustable) minutes then last lag fan shall be staged off.

VFD Stage	Stage up Flow
1	0%
2	45%

M. Hot water building pumps
1. Pumps shall be lead/lag controlled per Paragraph 3.13B.5.
2. The pumping system shall be enabled when there are more than zero (adjustable) Heating Plant Requests and shall be disabled otherwise. Once enabled, the pumping system shall stay enabled for a minimum of 10 minutes. Once disabled, the pumping system shall stay disabled for a minimum of 10 minutes.
3. When the pumping system is enabled, the building DP control loop is enabled. The loop shall be a reverse-acting loop maintaining the differential pressure (DP) sensor at setpoint. The output of the loop shall range from 0 to 100% and mapped to pump speed and the hot water control valve software point HW-VLV-DP as shown in the figure and described below:



a. Point HW-VLV-DP is mapped from 0% to 100% as the DP loop output ranges from 0% to 50%.
b. Once the valve is wide open (DP loop at 50%), the lead pump shall start and its speed mapped from its minimum speed (see Paragraph 3.14D.8) to 100% as the DP Loop signal ranges from 50% to 100% as shown in the figure. The lead pump shall stop when the valve is below 50% open and the pump has run for a minimum of 5 minutes.
c. HW pumps shall be staged as a function of HW flow ratio (HWFR = actual flow divided by total plant design flow). When HWFR is above 47% for 10 minutes, start the lag pump. Both pumps shall receive the same speed signal when both are on. When HWFR is below 47% for 15 minutes, or the lead pump is commanded off, shut off the lag pump.
d. Differential pressure setpoint shall be reset using Trim & Respond logic per Guideline 36 with the following parameters. DP-MAX is the design DP setpoint determined under 230593 Testing, Adjusting and Balancing.

Variable	Value
Device	Any HW Pump
SP_0	DP-MAX
SP_{min}	1 psi
SP_{max}	DP-MAX
T_d	15 minutes
T	5 minutes
I	2
R	Cooling HWDP Reset Requests
SP_{trim}	-2%
SP_{res}	+3%
$SP_{res-max}$	+7%

4. HW Flow Limit
   a. Flow limit setpoint shall be the total pump design flow rate listed on drawings. The limit will ensure that one building does not take more flow than they are entitled to, starving other buildings.

b. When the pumping system is enabled, a proportional-only flow limiting loop shall be enabled to maintain measured flow at the flow limit setpoint. The output of the loop shall be a software point HW-VLV-FL ranging from 0 to 100%.

5. The signal to the CHW valve from the central plant shall be the smaller of the signal determined from the pressure control HW-VLV-DP and the flow limiting loop HW-VLV-FL.

N. Domestic Water Heating Plant

1. Recirculation pump shall operate when any AH unit serving the area that includes the toilet rooms served by the recirc pump is in Occupied Mode.
2. Alarms
   a. Generate a Level 4 maintenance alarm when pump has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.
   b. Pump alarm is indicated by the status input being different from the output command for 15 seconds.
      1) Commanded on, status off: Level 2. Do not evaluate alarm until the device has been commanded on for 15 seconds.
      2) Commanded off, status on: Level 4. Do not evaluate the alarm until the device has been commanded off for 60 seconds.
   c. Hot water supply temperature less than 110°F when recirculation pump is proven on: Level 2.
   d. DHW heater alarm: Level 2

O. Toilet Exhaust Fan

1. Exhaust fans shall operate when any of the associated system supply fans is proven on and any associated Zone Group is in the occupied mode.
2. Alarms
   a. Generate a Level 4 maintenance alarm when fan has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status input being different from the output command for 15 seconds.
      1) Commanded on, status off: Level 2. Do not evaluate alarm until the device has been commanded on for 15 seconds.
      2) Commanded off, status on: Level 4. Do not evaluate the alarm until the device has been commanded off for 60 seconds.

P. Metering Summaries

1. Provide metering summary separately for the following metering systems:
   a. Electrical power
   b. Potable water
2. Include all submeters including those mapped from equipment (e.g. VFDs, water treatment system, etc.)
3. Include “virtual meters” where loads are based on subtraction from or addition of other loads including:
   a. Electricity
      1) All HVAC equipment. Sum of all HVAC equipment meters (including those in VFDs)
      2) Lighting loads
         a) Each floor: Subtract plug load submeter from total floor power meter.
         b) Sum of all interior lighting loads
         c) Sum of all lighting including all exterior and garage lighting
      3) Plug loads: Sum of all plug loads
4. For each metering system:
   a. Provide the system 1-line riser diagram on a summary graphic with links to subsections of the system by floor and major system.

b. On each subsection, indicate meter and virtual meter location with a title indicating end-use.
c. Through a hyperlink, show a screen summarizing meter data including:
1) Details of what is being metered
2) Pie chart or other graphical format
3) Summary of power on the following basis:
a) Current
b) Past day
c) Past month
d) Past year and year-to-date

5. Summary dashboards:
a. For both electricity and water
b. Pie chart or other graphical format showing total whole building consumption with a breakdown of the consumption by end-use, including the percentage of the total.

Q. Equipment not controlled or monitored by BAS system
1. Equipment Room Transfer Fans
a. Set setpoint to energize fan when space temperature rises above 85°F with 2°F differential.

R. Miscellaneous Alarms
1. Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output: Level 4
2. Equipment alarm (for equipment with alarm contacts such as VFDs, AC units): Level 2
3. Failure or disconnection of a sensor as indicated by signal widely out of range: Level 2.
4. Panel or LAN failure: Level 2
5. Loss of communication with any device via Gateway (e.g. VFD) for more than 30 seconds: Level 2 (alarm shall indicate which specific device is not responding).

3.14 SYSTEM COMMISSIONING

A. Sequencing. The following list outlines the general sequence of events for submittals and commissioning:
1. Submit Submittal Package 0 (Qualifications) and receive approval.
2. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.
3. Initiate installation of BAS hardware, devices and wiring.
4. Develop point database and application software.
5. Simulate sequencing and debug programming off-line to the extent practical.
6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
7. Complete installation of BAS hardware, devices and wiring.
8. Install point database and application software in field panels.
9. Submit Submittal Package 3 (Pre-Functional Test Forms) and receive approval.
10. Perform BAS Pre-functional Tests (start up, calibration and tuning) and submit completed forms as Submittal Package 4 (Pre-Functional Test Report) for approval.
11. Receive BAS Pre-functional Test Report approval and approval to schedule Functional Tests.
12. Field test application programs prior to functional testing.
13. Submit Package 5 (Post-Construction Trend Points List) in format specified for review and approval.
14. Receive approval of successful Trend Log configuration, or reconfigure as required.
15. Prepare and initiate commissioning Trend Logs.
16. Perform and record functional tests and submit Submittal Package 6 (Functional Test Report) for approval.

a. Some tests may not be possible due to weather conditions. These tests may be deferred to post-occupancy period.

17. Assist in TAB tests and determining setpoints as specified in Section 230593 Testing, Adjusting and Balancing.
18. Assist in Title 24 Acceptance Testing as specified in Section 230800 Mechanical System Commissioning.
19. Submit Package 7 (Training Materials) and receive approval.
20. Receive BAS Functional Test Report approval and approval to schedule Demonstration Tests.
21. Perform Demonstration Tests to Commissioning Provider and Owner's Representatives and submit Demonstration Test Report.
22. Receive acceptance of Demonstration Tests.
23. Train Owner personnel on BAS operation and maintenance.
24. Substantial Completion
25. Submit Package 8 (Post-Construction Trend Logs) in format specified for review and approval.
26. Receive approval of successful Trend Log tests, or retest as required.
27. Complete all items in Completion Requirements per Paragraph 1.7B.
28. Provide administration level password access to the Owner.
29. Final Acceptance
30. Begin Warranty Period.
31. Prepare and initiate continuous Trend Logs per Paragraph 2.12A.4.
32. Receive amended BAS Functional Test Report approval.
33. Two months prior to end of Warranty Period, submit Package 9 (End-of-Warranty Trend Logs) in format specified for review and approval.
34. Receive approval of successful Trend Log tests, or retest as required.
35. Revise and submit record documents and O&M Manuals.
36. Update all software as specified.
37. End of Warranty Period

B. Assist Commissioning Provider/Coordinator as specified in Section 019100 Commissioning, including attending commissioning meetings.

C. Coordinate with Work specified in Section 230800 Mechanical Commissioning and Division 26 Electrical Commissioning.

D. Pre-functional tests
   1. General
      a. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
      b. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
      c. Verify integrity/safety of all electrical connections.
      d. Verify that shielded cables are grounded only at one end.
      e. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.
   2. Test Documentation
      a. Prepare forms to document the proper startup of the BAS components.
      b. All equipment shall be included on test forms including but not limited to
         1) Wiring: End-to-end checkout of all wiring at terminations. Power to all controllers and actuators. Confirmation of emergency power where specified.
         2) Digital Outputs: Proper installation, normal position, response to command at CU
         3) Digital Inputs: Proper installation, device test, response at CU

4) Analog Outputs: Proper installation of devices, verification of maximum and minimum stroke.
5) Analog Inputs: Proper installation of sensors, calibration
6) Panels: Confirmation of location, power source (electrical circuit used), confirmation of emergency power where specified.
7) Alarms and Safeties: Verification of alarm routing to all specified devices and correct hierarchy. Example: confirm alarm routing to cell phones, email, servers, remote workstations. Confirm that appropriate alarm levels are routed to appropriate devices.
8) Loop Tuning: Document setting of P/I parameters for all loops, chosen setpoints, time delays, loop execution speed.
9) Network Traffic: Document speed of screen generation, alarm and signal propagation in system with all required commissioning trends active.

c. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
d. Submit blank forms for approval in Submittal Package 3.
e. Complete work, document results on forms, and submit for approval as Submittal Package 4 (Pre-Functional Test Report).

3. Digital Outputs
   a. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
4. Digital Inputs
   a. Adjust setpoints, where applicable.
      1) For current switches used as status on fans, adjust current setpoint so that fan status is OFF when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
      2) For current switches used as status on pumps, adjust current setpoint so that pump status is OFF when pump is dead-headed (temporarily close discharge valve).
      3) For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).
5. Analog Outputs
   a. Verify start and span are correct and control action is correct.
   b. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
   c. Check all normal positions of fail-safe actuators.
   d. For outputs to reset other manufacturer's devices (for example, chiller setpoint) and for feedback from them, calibrate ranges to establish proper parameters.
6. Analog Input Calibration
   a. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:
      1) Factory: Calibration by factory, to standard factory specifications. Field calibration is not required.
      2) Handheld: Field calibrate using a handheld device with accuracy meeting the requirements of Paragraph 2.10.
   b. The calibrating parameters in software (such as slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician indicating date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
   c. Inaccurate sensors must be replaced if calibration is not possible.
7. Alarms and Interlocks

a. A log shall be kept and initialed by the technician indicating date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.
b. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
c. Coordinate with Division 26 to test fire and life safety systems alarm contacts.
d. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
e. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

8. Variable Frequency Drive Minimum Speed
   a. Minimum speed for VFD-driven fans and pumps shall be determined in accordance with this Paragraph. Tests shall be done for each piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing motor losses to be minimal at low speeds.
   b. This work shall be done only after fan/pump system is fully installed and operational.
   c. Determine minimum speed setpoint as follows:
      1) Start the fan or pump.
      2) Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.
      3) Observe fan/pump in field to ensure it is visibly rotating.
         a) If not, gradually increase speed until it is.
      4) The speed at this point shall be the minimum speed setpoint for this piece of equipment.
      5) Record minimum speeds in log and store in software point as indicated in Guideline 36.
9. Tuning
   a. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted)

Controlled Variable	Control Accuracy
Duct Pressure	±0.1 inches w.g.
Building and relief plenum	±0.01 inches w.g.
Airflow and water flow	±10%
Space Temperature	±1.5ºF
Condenser Water Temperature	±2ºF
Chilled Water Temperature	±1ºF
Hot Water Temperature	±3ºF
Duct Temperature	±2ºF
Water Differential Pressure	±1.5 psi
Others	±2 times reported accuracy

10. Interface and Control Panels
    a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.

b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
c. Check power supplies for proper voltage ranges and loading.
d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
e. Check for adequate signal strength on communication networks.
f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
g. Ensure that buffered or volatile information is held through power outage.
h. With all system and communications operating normally, sample and record update and annunciation times for critical alarms fed from the panel to the Operator Interface.
i. Check for adequate grounding of all BAS panels and devices.

11. Operator Interfaces
    a. Verify that all elements on the graphics are functional and are properly bound to physical devices or virtual points, and that hot links or page jumps are functional and logical.
    b. Verify that the alarm, logging, paging, emailing etc. are functional and per requirements.

E. Testing, Adjusting, and Balancing (TAB) Coordination
1. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing. Some balancing procedures require the BAS to be operational and require Contractor time and assistance.
2. Calibration Software
    a. Software shall be provided free of charge on at least a temporary basis to allow calibration of terminal box airflow controls and other Work specified under Section 230593 Testing, Adjusting, and Balancing.
    b. Software shall be provided for installation on POT(s) provided by Others or Contractor shall loan a POT or handheld device with software installed for the duration of Work specified under Section 230593 Testing, Adjusting, and Balancing.
    c. Provide sufficient training to those performing Work specified under Section 230593 Testing, Adjusting, and Balancing to allow them to use the software for balancing and airflow calibration purposes. Contractor shall include a single training session for this purpose.
3. Setpoint Determination
    a. Perform pre-functional tests described in Paragraph 3.14D before assisting in setpoint determination.
    b. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing to determine fan and pump differential pressure setpoints, outdoor air damper minimum positions and DP setpoints, etc. as indicated in Section 230593 Testing, Adjusting and Balancing.
4. Coil Valve Leak Check
    a. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing to provide control valve leak check tests.

F. Functional Tests
1. Test schedule shall be coordinated with the Commissioning Provider, Commissioning Coordinator, and Owner's Representative.
2. Functional tests may be witnessed by Owner's Representative at the Owner's option.
3. All approved Functional Tests shall be conducted by the Contractor with results confirmed and signed by the Contractor's start-up technician.
4. Test documentation

a. Owner's Representatives will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.
b. Review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc. and provide to Owner's Representative.
c. Complete work, document results on forms, and submit for approval as Submittal Package 6 Functional Test Report. Tutorials for using the functional test Excel workbook can be found here.

G. Demonstration Test
1. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Commissioning Provider. Tests will be designed to occur over no longer than 2 working days.
2. Schedule the demonstration with the Commissioning Provider and Owner's Representative at least 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.
3. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.
4. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Commissioning Provider will supply the test forms at the site at the start of the tests.
5. Demonstration tests may be witnessed by Owner's Representative at the Owner's option.
6. Contractor shall conduct tests as directed by and in the presence of the Commissioning Provider and complete test forms. Commissioning Provider will document the test results as the Demonstration Test Report after tests are complete.
7. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

H. Trend Log Tests
1. Trends shall be fully configured to record and store data to the server for the points and at the interval listed in Paragraph 2.11 as follows:
a. Commissioning: Configure trends prior to functional testing phase. Retain configuration until post-construction commissioning trend review has been completed successfully and accepted by the Owner's representative. Trends shall be deactivated after acceptance.
b. Continuous: After system acceptance, configure trends for the purpose of long term future diagnostics. Configure trends to overwrite the oldest trends at the longest interval possible without filling the server hard disk beyond 80%.
2. Post-Construction Trend Test
a. Trend logging shall not commence until Demonstration Tests are successfully completed.
b. Hardware Points. Contractor shall configure points to trend as indicated in the Commissioning Trend column listed in Paragraph 2.11 points.
c. Software Points. Include the following in trends of systems and zones whose hardware points are being trended as called for above. Time interval shall be the same as associated hardware point.
1) All setpoints and limits that are automatically reset, such as supply air temperature and fan static pressure setpoints, plus the points that are driving the reset, such as zone level cooling and static pressure requests
2) All setpoints that are adjustable by occupants
3) Outputs of all control loops, other than those driving a single AO point that is already being trended

4) System mode points (e.g. Warm-up, Occupied, etc.)
5) Global overrides such as demand shed signals
6) Calculated performance monitoring points, such as chiller efficiency

d. Submit for review and approval by the Commissioning Provider a table of points to be trended along with trend intervals or change-of-value a minimum of 14 days prior to trend collection period, as Submittal Package 5.
e. Trends shall be uploaded to the CSS in data format specified in Paragraph 2.11C.3.
f. Trend logs of all points indicated above shall be collected for a 3 week Trend Period.
g. At the completion of the Trend Period, data shall be reviewed by the Contractor to ensure that the system is operating properly. If so, data shall be submitted to the Owner in an electronic format agreed to by the Owner and Contractor (such as flash drive or via direct access to the CSS via the internet) as Submittal Package 8.
h. Data will be analyzed by the Commissioning Provider.
i. The system shall be accepted only if the trend review indicates proper system operation without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps f to h above shall be repeated for the same Trend Period until there is a complete Trend Period of error free operation.
j. After successfully completing the Post-Construction Trend Tests, the Contractor shall configure all points to trend as indicated in the Continuous Trend column listed in Paragraph 2.11 points list.

3. End-of-Warranty Trend Tests
   a. Archive trends up to the CSS without overwriting stored data for the entire Warranty Period.
   b. At the completion of the End-of-Warranty Trend Period, data shall be submitted to the Owner in an electronic format agreed to by the Owner and Contractor (such as flash drive or via direct access to the CSS via the internet) as Submittal Package 9.
   c. Data will be reviewed by Commissioning Provider at approximately 30 days prior to the end of the Warranty Period.
   d. The system shall be accepted and warranty period considered complete only if the trend review indicates proper system operation without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps 2.f to 2.h above shall be repeated until there is a complete Trend Period of error free operation.

I. Remedial Work
   1. Repair or replace defective Work, as directed by Owner's Representative in writing, at no additional cost to the Owner.
   2. Restore or replace damaged Work due to tests as directed by Owner's Representative in writing, at no additional cost to the Owner.
   3. Restore or replace damaged Work of others, due to tests, as directed by Owner's Representative in writing, at no additional cost to the Owner.
   4. Remedial Work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the Owner's Representative, at no additional cost to the Owner.
   5. Contractor shall compensate Owner's Representatives and Commissioning Provider on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional BAS trends beyond the initial tests, at no additional cost to the Owner.

3.15 TRAINING

A. Coordinate schedule and materials with Commissioning Provider.

B. Interim Training
   1. Provide minimal training so the operating staff can respond to occupant needs and other operating requirements during start-up and commissioning phase.

C. Formal Training
   1. Provide training sessions for four building engineers.
   2. Submit training materials as Submittal Package 7.
   3. Training shall be conducted after all commissioning is complete and systems are fully operational.
   4. Primary System Training
      a. See Laney Central Utility Plant scope.
   5. On-Site Job Specific Training
      a. Include 40 hours total of on-site training to assist personnel in becoming familiar with site-specific issues, systems, control sequences, etc.
      b. Owner shall be permitted to videotape training sessions.
      c. Training may be in non-contiguous days at the request of the Owner.
   6. During the warranty period, provide unlimited telephone support for all trained operators.

D. Training materials shall include step-by-step instructions (including illustrations, screen captures, etc.) for how to perform all task identified in Paragraph 3.15C such that a new Operator, who has not attended the training in person and has minimal familiarity with this BAS system, can easily follow the instructions and successfully perform all of the identified tasks. One copy of training material shall be provided per student. An electronic copy of the materials shall be stored on the OWS.

E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260500
BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work included in this Section: All materials, labor, equipment, services, and incidentals necessary to provide and install the Electrical Work as shown on the drawings and as specified hereinafter, including, but not limited to the following:
   1. Electrical service provisions as outlined on the drawings, including temporary power for construction.
   2. Main switchboard, distribution switchboards, distribution panels, panels, transformers, circuit breakers, and feeders.
   3. Branch circuit wiring, wiring devices and connections to all equipment requiring electrical service.
   4. Lighting fixtures completely lamped, including switches, raceways and wiring.
   5. Emergency egress/exit illumination system.
   6. Mechanical equipment power connections, and motor starters where noted.
   7. Low voltage lighting control system and programming.
   8. Transient voltage suppression system.
   9. Medium voltage switchgear, transformers, and distribution system.
   10. All required incidental work, such as roof flashing, electrical testing, title 24 acceptance testing, and temporary power.
   11 Any other electrical work as might reasonably be implied as required, even though not specifically mentioned herein or shown on the drawings.
   12. It is the intent of the drawings and specifications that systems be complete and, except as otherwise noted, be ready for operation.

1.2 RELATED WORK

A. Division 1 - General Requirements

B. Division 9 - Finishes

C. Division 23 - Mechanical

1.3 INCORPORATED DOCUMENTS

A. Requirements of the General Conditions, Supplementary Conditions, and Division 1 Sections apply to all work in this Section, unless modified herein.

B. Published specifications, standard tests or recommended methods of trade, industry or government organizations apply to work of this Section where cited by abbreviations noted below, unless modified herein.
   1. 2019 California Code of Regulations.
   2. 2019 California Building Standards Administrative Code, Part 1, Title 24, C.C.R.
   3. 2019 California Building Code (CBC).
   4. 2019 California Electrical Code (CEC).
   5. 2019 California Mechanical Code (CMC).
   6. 2019 California Plumbing Code (CPC).
   7. California Energy Code, Part 6, Title 24, C.C.R.
   8. 2019 California Fire Code (CFC).

9. 2019 California Green Building Standards (CALGreen) Code.
10. Underwriters' Laboratories, Inc. (UL).
11. Local Utility Company regulations.

C. All State and Municipal Codes and Ordinances.

1.4 CONDITIONS AT SITE:

A. Visit to site is required of all bidders prior to submission of bid. All will be held to have familiarized themselves with all discernible conditions and no extra payment will be allowed for work required because of these conditions, whether specifically mentioned or not.

B. Lines of other services that are damaged as a result of this work shall promptly be repaired at no expense to the Owner to the complete satisfaction of the Owner.

1.5 QUALITY ASSURANCE

A. Conformance:
1. All work shall conform to the applicable requirements of Article 1.3 above.
2. The Contractor shall notify the Architect, prior to submission of bid, about any part of the design, which fails to comply with abovementioned requirements.
3. If after contract is awarded, minor changes and additions are required by aforementioned authorities, even though such work is not shown on the drawings or covered in the specifications, they shall be included at Contractor's expense.

B. Coordination:
1. The Contractor shall become familiar with the conditions at the job site, and with the drawings and specifications and plan the installation of the electrical work to conform with the existing conditions and that shown and specified so as to provide the best possible assembly of the combined work of all trades.
2. The Contractor shall work out in advance all "tight" conditions, involving all trades and if found necessary, supplementary drawings shall be prepared by this Contractor, for the Architect's approval, before work proceeds in these areas. No additional costs will be considered for work, which must be relocated due to conflicts with the work of other trades.
3. The Contractor shall coordinate and verify all backbox, device, lighting fixture, or equipment mounting requirements with the devices or equipment to be installed, prior to rough in.

1.6 SUBMITTALS

A. Product Data:
1. Comply with the provisions of Section 013300 - Submittals.
2. Within 15 days after award of the Contract, submit:
   a. Complete electrical, lighting, and signal systems material list of all items proposed to be furnished and installed under this Division. Provide manufacturers data sheets for all devices, raceways, fixtures, equipment, and related products to be used for the Division 26 work.
   b. Manufacturers' specifications and other data required demonstrating compliance with the specified requirements.
   c. Manufacturers' recommended installation procedures which, when approved by the Architect, shall become the basis for inspecting and accepting or rejecting actual installation procedures used on the work.
3. Shop Drawings: Furnish shop drawings and/or equipment cuts for the following:
   a. Light fixtures

b. Main Switchboard, distribution switchboards, distribution panels, panel boards, and transformers. Panel board submittals shall include diagrams of the circuit breaker arrangements in the panels. Arrange circuit breakers in panels exactly as shown on the panel schedules in the construction documents.
c. Disconnect switches
d. Motor starters
e. Low voltage lighting control system
f. Arc flash, Short Circuit, and Protective Device Coordination Study.
g. Power and signal concealed service floor boxes, and furniture panel infeed boxes.
h. Mechanical and Plumbing equipment. The Electrical Contractor shall review the Mechanical and Plumbing Submittals, and verify the voltage, wire size and overcurrent protection required. Also provide the Electrical Engineer with a copy of the submittals for their review.
l. Transient Voltage Surge Suppression system if specified herein and/or indicated on the drawings.
m. Medium voltage transformers, and cable if specified herein and indicated on the drawings.
n. Emergency Generator and Automatic Transfer Switches.

4. Test Reports:
   a. Factory Tests: As specified for specific equipment.
   b. Field Tests: Performance tests as specified for specific equipment.
   c. Megger Tests: As specified under TESTING.
   d. Special Seismic Certification documentation as per CBC Section 1616A and ASCE/SEI 7-10 requirements for all equipment defined as 'critical' with an importance factor of 1.5 in Paragraph 1.10.M.3 of this Section.
   f. Manufacturer's Seismic Certification or Project-Specific Design of Supports and Attachments for all other equipment and fixtures as per CBC Section 1616A and ASCE/SEI 7-10 requirements.
5. Maintenance and Operating Manuals:
   a. Systems Description: Description of operating procedures.
   b. Controls: Diagrams and description of operation of each system.
   c. Equipment: Manufacturer's brochures, ratings, certified shop drawings, maintenance data, and parts lists with part numbers. Mark each sheet with equipment identification number and actual installed condition.
   d. Materials and Accessories: Manufacturer's brochures, parts lists with part numbers, and maintenance data where applicable. Mark each sheet with identification number of system and location of installation.
   e.
6. Record Documents: "As-builts": As specified under Paragraph 3.2 of this Section.

1.7 DELIVERY, STORAGE AND HANDLING

A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation and to protect the work and materials of all trades.

B. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with approved manufacturers' recommendations.

C. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect and at no additional cost to the Owner.

D. This Contractor shall personally, or through an authorized representative, check all materials upon receipt at jobsite for conformance with approved shop drawings and/or plans and specifications.

1.8 SCHEDULING/SEQUENCING

A. Place orders for all equipment in time to prevent any delay in construction schedule or completion of project. If any materials or equipment are not ordered in time, additional charges made by equipment manufacturers to complete their equipment in time to meet the construction schedule, together with any special handling charges, shall be borne by this Contractor.

B. The Contractor shall coordinate production and delivery schedule for all Owner-supplied equipment with the equipment suppliers to ensure that all Owner-supplied equipment is delivered to site in coordination with the construction schedule and in such a manner as to cause no delays in completion of the Contract as scheduled.

1.9 REQUIREMENTS

A. The contract drawings indicate the extent and general arrangements of the conduit wiring systems, etc. If any departures from the contract drawings are deemed necessary by the Contractor, details of such departures and the reasons therefore shall be submitted as soon as practicable, and within thirty-five (35) days after award of the electrical contract.

B. Unless material list and data is received as a complete and all-inclusive submittal within the stipulated time all items shall be provided as specified, with no deviations permitted.

C. Any and all additional costs incurred by the substitution of electrical material or equipment, or installation thereof, whether architectural, structural, plumbing, mechanical or electrical, shall be borne by the Contractor under this Section.

D. Burden of proof of equality of any substitution for a specified product is the responsibility of this Contractor.

E. Where required by Architect to ascertain equality of substitute product, Contractor may be requested to provide the specified item and the submitted substitution for comparison, at no additional cost to the Owner.

1.10 SEISMIC CERTIFICATION AND INSTALLATION OF EQUIPMENT

A. See Architectural and Structural Drawings and Specifications for description of Occupancy Group and Seismic Design Category applicable to this project.

B. Provide Special Seismic Certification per CBC Section 1616A and ASCE/SEI 7-10 for all equipment and components defined as critical with an importance factor 1.5 in Paragraph 1.10.M.3 of this Section.

C. Special Seismic Certification shall require either certification through approved analytical method or approved shake table testing in accordance with Section 13.2.5 of ASCE/SEI 7-10 or experience data in accordance with Section 13.2.6 of ASCE/SEI 7-10.

D. Manufacturer's Seismic Certification or Project-Specific Design of Supports and Attachments for all other equipment and fixtures as per CBC Section 1616A and ASCE/SEI 7-10 requirements.

E. Provide seismic restraints per applicable code and as specified or indicated. Design restraints to prevent permanent displacement in any direction caused by lateral motion, overturning, or uplift.

F. Rigidly Supported Equipment, Conduits, and Raceways.

G. Lighting:
   1. Fasten lighting fixtures in suspended ceilings to ceiling grid system or otherwise support from the structures as specified herein and as per details indicated on the Drawings. Comply with National Electric Code (NEC) Article 410.
   2. Suspension systems for light fixtures shall allow fixtures to swing a minimum of 45 degrees from the vertical in all directions without contacting obstructions.
   3. Free-swinging suspension systems shall have a safety wire or cable attached to the fixture and structure at each support. The wire shall be capable of supporting four times the weight of the lights.
   4. Point-source fixtures: provide slack wires to structure at two diagonal corners.
   5. Troffer fixtures: provide hold-down clip at each fixture corner, and slack wires to structure at two diagonal corners.
   6. Supports for pendants: Provide diagonal seismic wire restraints per Code.

H. Components supported by chains or simply suspended from above are not required to meet lateral seismic force requirements and seismic relative displacement requirements provided that they cannot be damaged or cannot damage any other component when subject to seismic motion. They must have ductile or articulating connections to the structure at the point of attachment.

I. Electrical Cabinets:
   1. Electrical cabinet design shall conform to National Electrical Manufacturers Association (NEMA) 250 and NEMA ICS6 standards. Cutouts in the lower shear panel that do not appear to have been made by the manufacturer and significantly reduce the strength of the cabinet are not permitted unless analysis demonstrates that the remaining strength is sufficient.
   2. Single freestanding cabinets shall have a minimum of four anchor bolts designed and specified with one anchor located at each corner.
   3. Multiple sections of cabinets or enclosures located adjacent to each other shall be bolted together. Minimum acceptable bolting is three bolts in the front and back along the adjacent vertical faces - 6 bolts total.
   4. Multiple cabinets bolted together to form a section or line-up shall have at a minimum two anchors specified for each cabinet, one at the front and one at the rear.
   5. Base anchorage shall be installed through anchor points designated by the Manufacturer. The largest bolt diameter for the anchor hole provided in the equipment shall be provided.
   6. A latch or fastener to prevent opening during an earthquake event and damaging the cabinet and internal components shall secure all doors.
   7. Slide-out components in electrical control panels, etc., shall have a latching mechanism to hold contents in place.
   8. Attached cabling shall have adequate slack or flexibility between the cabinets and surrounding structure supporting the conduit to preclude severing of the cabling due to differential seismic displacements.

J. The design load shall include the effects of loading on the equipment imposed by attached utility or service lines that are also attached to separate structures.

K. The attachment of additional external items is not permitted unless such items have either been provided by the Manufacturer, or analysis shows that their effects are supported by design.

L. Conduit and their connections shall be constructed of ductile materials unless otherwise approved by the Architect. Conduits and their connections constructed of non-ductile materials (e.g., cast iron, no-hub pipe and plastic) shall have brace lengths reduced to one-half that allowed for ductile material.
   1. All trapeze assemblies supporting conduit shall be braced to resist CBC design forces considering the total weight of the elements on the trapeze.
   2. Seismic restraint spacing shall be in accordance with hanger spacing.

M. Critical Equipment:
   1. Design with importance factor of 1.5.
   2. Provide Special Seismic Certification for all equipment and components and their installation per CBC and ASCE/SEI requirements.
   3. Critical Equipment shall include the following:
      a. Emergency Generator and Automatic Transfer Switches if specified herein and/or indicated on the drawings.
      b. Emergency power systems switchboards, distribution panels, transformers, and panelboards if specified herein and/or indicated on the drawings.
      c. Low Voltage Relay Panels on Emergency Power

N. Seismic Design Submittals: For all Critical Equipment included in paragraph 26 05 00.1.10.M.3.
   1. The Manufacturer of each item of critical equipment shall arrange for the testing or analysis by an approved agency of each component and assembly and its mounting system or anchorage.
   2. The Manufacturer shall submit a Certificate of Compliance for each item for approval by the Architect and by the Authority Having Jurisdiction.
   3. Based on Manufacturer's approved submittal, Contractor shall retain the services of a State of California registered Structural Engineer to prepare final installation details and drawings for equipment supports and attachments.
   4. Submit drawings of the equipment showing dimensions, support equipment, connections, and the proper anchorage locations.
   5. Equipment weight and weight distribution (e.g., center of gravity in elevation and plan).
   6. Thickness of sheet metal bases.
   7. Seismic Vibration Isolation Devices: Manufacturer's product information indicating class and type. Indicate load ratings as published manufacturer's data or shop drawings. Indicate proper orientation of devices on plan.
   8. Inertia bases and support frames.
   9. Specific details of restraints including anchor bolts and welds and maximum load at each location.

O. Independent Supports: An independent means of secure support shall be provided for all wiring methods in non-fire-rated assemblies. Where independent support wires are used, they shall be distinguishable by color, tagging, or other effective means.

1.11 DESCRIPTION OF DEMOLITION AND REPLACEMENT WORK

A. This project includes the demolition and replacement, modification, or enhancement of existing facilities. As such, the project scope for this contractor shall include all associated electrical, lighting, and signal system upgrades and demolition/removal work at the existing buildings(s) and/or site. The intent is that all systems will be complete and functional at the completion of this contract and that all old systems, equipment, feeders, circuits, wiring, and related devices (no longer used) be completely and neatly removed. Where discrepancies between the drawings and existing conditions are noted, the Architect or Owner shall be notified immediately for resolution.

B. As with every renovation project, the electrical work will include (and require) exploration and other field work on a daily basis to complete the new designed equipment and connections within the constraints of the existing building and existing site conditions.

C. The contractor shall include as part of the base bid, sufficient labor hours to provide such exploration and field work throughout the duration of the project. Change orders for miscellaneous coordination of existing conditions will not be approved unless specific and latent conditions are uncovered that warrant such additional compensation or require additional work not shown on the drawings or included in the specifications, or implied by the designed conditions.

D. New raceways and wiring to new and renovated equipment are to be installed unless otherwise noted. Where raceways are installed in accessible concealed locations (i.e. unfinished spaces or electrical / mechanical / attic spaces), EMT with wire shall be used. Where new wiring is required to be routed through existing walls and ceilings that cannot readily be accessible for new conduit, MC cable or flex conduit and wiring may be installed, fished through and secured in each space as required by Code. Non-metallic sheathed cable shall not be utilized on this project.

E. All new raceways shall be installed concealed and all new equipment installed flush, unless otherwise noted on the drawings or in these specifications.

1.12 GUARANTEE

A. This Contractor shall guarantee that all work executed under this Section will be free from defects of materials and workmanship for a period of one (1) year or as per the General Conditions of this project, whichever is longer. Dates shall be from the date of final acceptance of the building. The contractor shall further guarantee that he will, at his own expense, repair and replace all such defective work, and all other work damaged thereby, which becomes defective during the term of the guarantee. Such repair or replacement shall be guaranteed for one (1) year from the date of repair or replacement.

1.13 PERMITS AND INSPECTIONS

A. This Contractor shall arrange for and obtain all required permits and inspections.

B. Do not allow or cause any of the work to be covered or enclosed until it has been tested and/or inspected.

1.14 IDENTIFICATION

A. Switchgear, switchboards, distribution panels, and feeder circuit breakers therein, panels, disconnect switches, motor starters, transformers, motor disconnect switches, cabinets, and other apparatus used for the operation of, or control of circuits, appliances or equipment, shall be properly identified by means of engraved laminated plastic descriptive nameplates mounted on apparatus using stainless steel screws. Nameplates shall have white letters with black background and be submitted to the Architect for approval. Cardholders in any form are not acceptable.

B. Provide p-touch style labeling of circuit designations for all receptacles on the project.

C. Each branch circuit of panel boards to have a permanently fixed number with load directory, mounted under celluloid on inside of cabinet door, showing circuit numbers and typewritten description of equipment supplied by breakers. Where changes are made to existing panelboards, newly typewritten circuit directories shall be prepared to replace existing directories.

D. Provide label on all motors: "Caution. Automatic equipment. May start at any time."

E. Provide silk-screened or engraved identification labels on all switch box covers identifying specific loads that are not readily apparent to the user, including electroshades, projection screens, exhaust fans, audio-visual controls, etc.. Submit proposed labels to Architect for approval prior to manufacture of labels.

F. Provide identification of all pull boxes, junction boxes, and conduit stub-ups on the project as outlined below:
   1. For Power Feeders:
      a. Stencil cover with identifying circuit number.
      b. Lettering 1" high.
      c. Color of lettering black.
      d. Place lettering on cover in neat manner; run parallel to long sides of box.
   2. For branch circuits, grounding, communication, signal, and control systems boxes and blank conduit stub-outs:
      a. Paint inside back of each j-box, front of each cover, and ends of each blank conduit stub-out with identifying system color as listed below:

1)	277/480-volt	Orange
2)	120/208-volt	Blue
3)	Telephone/Data	Grey
4)	Ground system	Green
5)	Lighting control	Orange/White
6)	Emergency Power 277V	Orange/Red
7)	Emergency Power 120V	Blue/Red

PART 2 - PRODUCTS

2.1 GENERAL

A. Refer to applicable Division 26 Sections for complete products specifications.

2.2 MATERIALS

A. Materials of the same type or classification, used for the same purpose, shall be the product of the same manufacturer.

2.3 ACCEPTABLE MANUFACTURERS

A. Materials shall be of make mentioned elsewhere in this specification. All materials shall be the best of their several kinds, perfectly new and approved by the Underwriters' Laboratories.

B. Where material, equipment, apparatus or other products are specified by manufacturer, brand name, type or catalog number, such designation is to establish standards of desired quality, style and utility and shall be the basis of the bid. Materials so specified shall be furnished under the contract unless changed by written approval of the Architect. Where two or more designations are listed, choice shall be optional with this Contractor, but this Contractor must submit his choice for final approval.

2.4 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment where indicated in the technical sections for use by operation and maintenance personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system

and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions as directed. Attach or post operating instructions adjacent to each principal system and equipment including startup, proper adjustment, operating, lubrication, shutdown, safety precautions, procedure in the event of equipment failure, and other items of instruction as recommended by the manufacturer of each system or equipment. Provide weather-resistant materials or weatherproof enclosures for operating instruction exposed to the weather. Operating instruction shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

2.5 CATALOGED PRODUCTS/SERVICE AVAILABILITY

A. Materials and equipment shall be current products by manufacturers regularly engaged in the production of such products. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The 2-year period shall be satisfactorily completed by a product for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished. The equipment items shall be supported by service organizations which are reasonable convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions under which the work of this Section will be installed. Correct conditions detrimental to the proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Drawings:
   1. The general arrangement and location of wiring and equipment is shown on the electrical drawings and shall be installed in accordance therewith, except for minor changes required by conflict with the work of other trades.
   2. The Contractor shall coordinate and verify all backbox, device, lighting fixture, or equipment mounting requirements with the devices or equipment to be installed, prior to rough in.
   3. Drawings indicate the circuit and panel which supplies each device or fixture. Provide and install conduit and conductors to make all connections from panel to nearest device and from first device to additional devices on same circuit. Conduit size and fill shall satisfy NEC requirements. Do not exceed 4 #12 or 3 #10 conductors in a ½" conduit, 7 #12 or 5 #10 in a 3/4" conduit, and 11 #12 or 9 #10 in a 1" conduit, unless otherwise noted. Provide common handle-tie on breakers for multi-wire branch circuits (with common neutral), per NEC. If more than three current carrying conductors are installed in one conduit, conductor size shall be increased as required per NEC. Do not share neutrals for branch circuits.
   4. Drawings indicate the location of all light switches. Where fixtures in a room are controlled by more than one switch, the same lower case letter is drawn adjacent to a switch and each fixture controlled by that switch. Where no lower case letter is adjacent to a switch, all fixtures in the room are controlled by that switch. Provide and install conduit and wire from fixture to switch and between fixtures as required to accomplish switching shown. Do not route branch circuit wiring for light fixtures through switch boxes. Where dimming

controls are specified, provide required dimming control wiring in addition to power wiring from control device to all controlled light fixtures. Provide separate conduit for dimming control wiring unless otherwise indicated on the drawings.

5. Drawings indicate location of all signal outlet boxes. Provide and install conduit system as required and complete system wiring, unless otherwise noted.
6. Control wiring is generally not shown on the plans. Contractor shall refer to control diagrams and provide and install all wiring and raceways required to make all interconnections.
7. All branch circuit wiring No. 12 or No. 10 as noted, all control wiring No. 14, except as noted next to "slash marks" on the drawings, or as noted under "Wire," as specified herein.
8. All dimensions, together with locations of doors, partitions, etc. are to be taken from the Architectural Drawings, verified at site by this Contractor.
9. Maintain "as-built" records at all times, showing the exact location of concealed conduits and feeders installed under this contract, and actual numbering of each circuit. Upon completion of work and before acceptance can be considered, this Contractor must forward to the Architect, updated CAD plans, corrected to show the electrical work as actually installed.
10. Branch circuit conductors shall be #12 minimum and #10 minimum for runs longer than 150 feet.

B. Measurements: Before ordering any material or closing in any work, verify all measurements on the job. Any differences found between dimensions on the drawings and actual measurements shall be brought to the Architect's attention for consideration before proceeding.

3.3 FIELD QUALITY CONTROL

A. All workmanship shall be first class and carried out in a manner satisfactory to and approved by the Architect.

B. This Contractor shall personally, or through an authorized and competent representative, constantly supervise the work and so far as possible keep the same foreman and workmen on the job throughout.

3.4 COORDINATION

A. In electrical rooms, where electrical equipment is located at walls with brace framing, provide and install steel channel supports for mounting of electrical equipment away from wall to avoid conflict with brace framing. Steel channel supports shall be unistrut or equal, and shall include all channels, bases, fittings, etc., as required for a complete installation.

B. In electrical rooms, Contractor is responsible for installation of electrical equipment within the space provided. Contractor shall provide ¼" scale plans of electrical room layouts, and elevations of steel channel supports (where used or required) of electrical equipment for review and approval prior to any installation or rough-in

3.5 INSTALLATION/APPLICATION/ERECTION

A. All electrical raceways and devices shall be installed concealed (for raceways) and/or flush mounted (for devices), unless otherwise noted. Provide cut-in boxes and "fish" flexible MC or flex conduit and wire through existing walls to remain, unless shown otherwise on plans. Cut and patch to facilitate such installation to match adjacent and original finish.

B. All cutting, repairing and structural reinforcing for the installation of this work shall be done by the General Contractor in conformance with the Architect's requirements.

3.6 EMERGENCY POWER SOURCES

A. All emergency source circuits shall be installed in separate raceways (from normal power), per 2017 NEC 700.10(B), or the applicable code at the time of permitting.

3.7 TEMPORARY LIGHTING AND POWER

A. Provide and install temporary lighting and power systems for the duration of construction, of adequate size to accommodate the required lighting and power loads. Coordinate with other trades to insure adequate sizing.

B. Provide distribution equipment as required to support all construction activities.

3.8 FIRE STOPPING AND FIRE RATED PENETRATIONS

A. All electrical equipment mounted in, on, or through fire rated construction shall be installed to maintain the fire rating of the construction.

B. Provide fire rated pads (or other suitable assembly) around all electrical junction boxes in fire rated walls/ceilings/floors to maintain the fire rating.

C. Provide fire rated construction around all recessed light fixtures and/or panel board / cabinets mounted flush in fire rated walls to maintain the fire rating. Coordinate depth of construction with other trades to avoid conflicts.

D. Conduit sleeves shall be provided as a means of routing cables through fire-rated walls or floors. Openings in sleeves and conduits used for system cables and those which remain (empty) spare shall be sealed with an approved fireproof, removable sagging material. Sleeves which pass vertically from floor to floor shall be sealed in a similar manner using an approved re-enterable system. Additional penetrations through rated assemblies necessary for passage of tel/data wiring shall be made using an approved method and permanently sealed after installation of cables.

3.9 ADJUSTING AND CLEANING

A. All electrical equipment, including existing equipment not "finish painted" under other sections, shall be touched up where finished surface is marred or damaged.

B. All equipment, lighting fixtures, etc., shall be left in clean condition, with all shipping and otherwise unnecessary labels removed there from.

3.10 SCHEDULES

A. Coordination: Coordinate installation of electrical items with the schedule for other work to prevent unnecessary delays in the total Work.

3.11 WARNING SIGN MOUNTING

A. Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.12 PAINTING OF EQUIPMENT

A. Factory Applied: Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6 corrosion-resistance test, except

equipment specified to meet requirements of ANSI C37.20 shall have a finish as specified in ANSI C37.20.

B. Field Applied: Paint electrical equipment as required to match finish or meet safety criteria. Painting shall be as specified in the respective equipment section.

3.13 TESTS

A. Testing and inspection: See Section 260800 - Testing.

END OF SECTION

SECTION 260513

MEDIUM VOLTAGE DISTRIBUTION

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American National Standards Institute (ANSI) Publication (Latest Edition):

C2 National Electrical Safety Code

C. Institute of Electrical and Electronic Architects, Inc. (IEEE) Publication (Latest Edition):

48 Standard Test Procedures and Requirements for Alternating Current Cable Terminations 2.5KV through 765KV

386 Separable Insulated Connectors for Power Distribution Systems Above 600V.

400 Field Testing and the Evaluation of Insulation for Shielded Power Cable Systems

D. National Fire Protection Association (NFPA) Publication (Latest Edition):

70 National Electrical Code (NEC)

E. Underwriter's Laboratories, Inc. (UL) Publications (Latest Edition):

UL 1072

F. State of California Public Utilities Commission (Cal. P.U.C.) Publication:

G.O. 128 Rule for construction of Underground Electric Supply and Communication Systems.

G. AEIC CS6-96: Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69 kV

H. ASTM B8-04: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

I. ICEA S-93-639/NEMA WC74: Shielded Power Cables Rated 5 – 46 kV

J. ICEA S-97-682: Utility Shielded Power Cables Rated 5 - 46 kV

1.2 SUBMITTALS

A. Submittals: Submit the following information for approval:
1. Manufacturer's Data and Shop Drawings:
   a. Conduit
   b. Medium Voltage Cables
   c. Medium Voltage Splice Kits
   d. Medium Voltage Terminating Kits

e. Medium Voltage Connectors
f. Terminators
g. Fault Indicators

2. Manufacturer's and Installer's Experience: Submit evidence documenting manufacturer's ten-year experience in medium voltage cable and accessories manufacturing. Submit manufacturer's data on electrical cable and terminations. Contractor shall submit a list of previous work evidencing at least five years experience in medium voltage cable installation of similar type. Submit name and experience record of each person to be engaged in medium voltage cable work. Only those persons accepted by the Owner will be permitted to engage in medium voltage cable work.
3. Cable Test Reports:
   a. Three copies of factory test records on a per-reel basis shall be furnished at the time of cable shipment. The data shall include the following items: Purchase order and date; description of cable; description of sample high voltage test; dielectric loss and P.F. test; bending test; marked length and actual conductor resistance at 25 degrees C.; insulation resistance in megohms at the testing temperature of each reel length of cable or insulation resistance in megohms at the standard temperature of 15.5 degrees C. per 1000 feet of the cable supplied in this order; sheath integrity and thickness.
   b. The maximum current carrying capacities and maximum safe operating temperatures on the basis of 3 equally loaded single conductor cables in underground ducts at 100 percent and at 75 percent load factors, and on the basis of 90 RHO, 20 degrees C. ambient and 80 degrees C. conductor temperatures, shall be stated. (Three cables in one duct.)
4. Certificates:
   a. Workmen's Competency: Submit high voltage cable Splicer/Terminator certification of competency and experience 30 days before splices or terminations are made in high voltage cables. Splicer/Terminator experience during the immediate past 3 years shall include performance in splicing and terminating cables of the type and classification being provided under this contract.
   b. Before assigning any cable splicer to work covered by this specification, the Contractor shall provide the Owner with the names of the cable splicer to be employed, together with satisfactory proof that each splicer has had at least 3 years experience in splicing high-voltage cables and is experienced with the type and rating of cables to be spliced.
5. Contractor to submit a medium voltage cable pulling plan complete with calculations and layout. Cable pulling plan shall include but not be limited to the actual calculations of jam ratios, sidewall bearing pressures and maximum pulling tensions using pulling eyes or cable grips for each run. Also, provide cable information on the plan and diagram of each pull run.
6. Contractor to provide submittal of lubricants.
7. Submit shipping and handling protocol.

1.3 COORDINATION AND SCHEDULING

A. Coordinate with the Owner for the interception of existing underground medium voltage distribution conductors where indicated on the drawings. Comply with all Owner requirements for splicing and rerouting of existing conductors.

B. It is the responsibility of the Contractor to arrange for all services with the Owner and to ensure that all conduit and other service provisions are as required by the Owner prior to installation of these service provisions. No extra payments will be made to the Contractor as a result of his failure to fully coordinate with the Owner.

C. Location of existing utilities: Although the Architect has endeavored to show all underground or above ground utilities at the project site, all utility locations are not necessarily known nor shown. The Contractor is cautioned that the utilities encountered at the site include communication cables and electrical cables conducting high voltage, as indicated. When excavating in the vicinity of such cables, special precautions are to be observed by the Contractor at his own cost and shall include the following: All cables and their enclosure ducts shall be exposed by careful hand excavation so as not to damage the ducts or cables nor cause injury to persons, and suitable warning signs, barricades, and safety devices shall be erected whenever necessary or appropriate.

D. Provide schedule notification to the Owner 5 working days prior to medium voltage testing.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials and equipment shall conform to the Owner's Standards and to the specifications herein. Electrical ratings shall be as indicated.

2.2 MATERIALS

A. Conduit:
   1. See Section 262700.

B. Tape: UL 510. Plastic insulating tape shall be capable of performing in a continuous temperature environment of 80 degrees C.

C. Power Wire and Cable:
   1. Wire and Cable Conductor Sizes: American Wire Gauge (AWG) designates wire and cable conductor sizes. Conductors shall be copper. Insulated conductors shall bear the date of manufacture imprinted on the wire insulation with other identification. Wire and cable manufactured more than 6 months before delivery to the job site shall not be used. Provide conductor identification within each enclosure where a tap, a splice or a termination is made.

D. Medium Voltage Wires and Cables: 15KV single conductor, Class B concentric stranded copper, compact round type, bare or annealed uncoated copper per ASTM B-496, size as noted on the drawings. Underwriters' Laboratories shall list Cable as 15,000-volt power cable type MV-105, the cable shall bear the U.L label, and shall be rated for installation in wet or dry conditions. Cables shall be designed to operate continuously at 105 degrees C for normal operation; 140 degrees C for emergency overload conditions, and 250 degrees C for short circuit conditions.
   1. Strand Screen: Extruded semi-conducting EPR (ethylene propylene rubber) layer over conductors.
   2. Insulation: The insulation shall be type EPR, 133 percent insulation level, 220 mils.
   3. Insulation Screen: The insulation shall be screened by an extruded semi-conducting EPR layer. The thickness shall be in accordance with the referenced standards.
   4. Shield: 5 mil bare copper tape helically applied with 12.5% nominal overlap.
   5. Medium voltage shield drain wrap half-lapped shall not exceed 12.5%.
   6. Outer jacket: Black polyvinyl chloride jacket, 80 mils, surface printed, water, oil, alkali, and sunlight resistant.
   7. Strand Screen, Insulation, Insulation Screen, and Jacket shall meet ICEA S-93-639 / NEMA WC74, ICEA S-97-682, AEIC CS8 and U.L 1072 standards.

8. The manufacture, reeling, testing, certification and shipping of this cable shall be in accordance with IEEE-48 standards.
9. All factory serial numbers of reels and all other markings must match identically with those shown on the Factory test certificates.
10. Each reel must have one pulling-eye attached to outer cable end.
11. Medium voltage conducting thermosetting compound shall be compatible with both the insulation and the conductor and have an allowable operating temperature equal to that of the insulation.
12. Cable ratings shall include medium voltage emergency overloads for up to 1,500 hours cumulative through the life of the cable.
13. The cable must be free stripping without the use of heat cutting or the need of machine removal.
14. Cable Warranty: 40 years from date of shipment.
15. Provide stranded copper ground conductor in each conduit with phase conductors. Size for ground conductor shall be as indicated in Section 26 24 00 or on the drawings.

E. Terminations and splices shall be rated as follows:

Voltage:	BIL: 110kV, 1.2 X 50 microseconds
Withstand:	50kV, 60 Hz, 1 minute 75kV, DC, 15 minutes
Corona:	19 kV extinction
Current:	Continuous: Equal to cable ampacity – see drawings 8-hour overload: 150% of cable ampacity
Momentary:	25,000 amps, RMS, 12 cycles 10,000 amps, RMS, .5 seconds 3,500 amps, RMS, 3.0 seconds
Production Tests:	Applied Potential: 50kV, 60 Hz, 1 minute Corona: 19kV extinction Test Point: Verify operation

F. Medium Voltage Terminations (Indoor):
1. Medium Voltage Cable Terminations: IEEE 48 Class 1. The manufacturer shall provide all components, materials and complete instructions for installations, which shall include stress relief devices.
2. Terminators: Shall be modular, molded rubber type: IEEE 48 Class I. Provide terminator as specified herein for terminating single conductor, solid insulated, nonmetallic jacketed type cables for service voltage up to 15 KV. The terminator shall consist of stress control, ground clamp, non-tracking rubber skirts, crimp-on connector, rubber cap, and serial lug. Separate parts of copper or copper alloy shall not be used in contact with aluminum or aluminum alloy parts in the construction and installation of the terminator.

G. Medium Voltage Terminations (Outdoor):
1. Terminators shall be 600 ampere, non-loadbreak, separable elbow type, Elastimold Type 655LR or equal, with shield terminator with appropriate shield adapt kit.
2. Terminators shall be fully shielded, fully submersible, designed for energized operation.
3. Terminators shall be of the materials and construction to ensure dead front construction, shielding, and proper creep path length and water seal. An integral

voltage test point and a reinforced pulling ring of stainless steel shall enable the elbow connector to be removed with a shotgun tool. The crimp-type connector for the cable conductor shall meet all requirements of TDJ-162 for Class "A" connectors. A copper pin incorporating Belleville washers at the engagement point with conductor contact shall ensure the integrity of the electrical connection and result in the total connector system meeting Class "A" connector requirements. A stainless steel hold down bail shall mechanically lock the elbow connector onto the bushing.

4. All separable connectors and junctions shall comply with IEEE-386.

H. Splices: Splicing shall be allowed only with the prior permission of the Owner and will be allowed only if cable cannot be installed in one continuous piece without splice. Splices shall be made using a "kit" which shall be the product of one manufacturer and shall have the approval in writing of the manufacturer of the cable, which is to be spliced. Splice shall be suitable for continuous immersion in water. Kit shall be modular, molded rubber type, and shall be as manufactured by Raychem HVS-1520S Series for Heat-Shrinkable splice and Elastimold 655LR Series Separable Connector for elbow splice, or approved equal.

1. Molded Kits shall be fully shielded, fully submersible, designed for energized operation.
2. Connectors shall be shielded, with proper creep path length and water-seal. The crimp-type connector for the cable conductor shall meet all requirements of TDJ-162 for Class "A" connectors.

I. Fault Indicators:

1. At elbow connectors provide and install Cooper Power Systems Type TPR or approved equal test point reset fault indicators. Fault indicators shall not trip due to mechanical forces caused by handling. An electric pulse shall turn the indicator's display. When line voltage is restored, the indicator shall reset in approximately 3 minutes. A semi-conductive molded rubber housing, epoxy encapsulated electronic componentry and sealed target window shall make indicator suitable for submersible applications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Cable installation shall conform to NFPA 70 and ANSI C2:

1. Ends of cable shall be taped immediately after cutting to prevent moisture from entering the cable. Where the cable is not expected to be connected for at least 72 hours, the tape shall also be varnished.
2. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.
3. Bends in cables shall have an inner radius not less than 12 times the cable diameter.
4. Leave a horizontal slack of approximately 3 feet on each end of cable runs, on each side of connection boxes, and at all points where connections are brought to equipment. Leave additional slack to make necessary connections.
5. Ground cable shielding, metallic sheath, and armor at each cable joint or splice by means of braided tinned copper wire connected to equipment grounding conductor. See Section 262400. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground wires shall be neatly and firmly attached to pullbox walls and the amount of exposed bare wire shall be held to a minimum.

B. Cable Pulling: Test raceways with a mandrel and thoroughly swab out to remove foreign material before the pulling of cables. Pull cables down grade with the feed-in point at the pullbox or equipment enclosure of the highest elevation. Use flexible cable feeds to convey

cables through the pullbox opening and into the raceway runs. Cable slack shall be accumulated at each junction box where space permits by training the cable around the interior to form one complete loop. Minimum allowable bending radii shall be maintained in forming such loops.

1. Lubricants for assisting in the pulling of jacketed cables shall be those specifically recommended by the cable manufacturer. Cable lubricants shall be soapstone, graphite, or talc for plastic jacketed cables. The lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.
2. Cable pulling tensions: Use a dynamometer and do not exceed a value of TM = number of conductors in the run, times the cross sectional area in circular mills, times the constant .011, or the maximum pulling tension recommended by the cable manufacturer, whichever is lower.
3. Installation of Cables in Pullboxes: Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form all cables to closely parallel walls, not to interfere with conduit entrances, and support on brackets and cable insulators at a maximum of 18 inches separation. Support cable splices by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space opening for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each pullbox.
4. Use nylon or manila rope.
5. Cable racks, supports and related fittings to be UL listed, cable iron insulators to be dry processed glazed porcelain, use industry standard equipment.

C. Observation by Owner’s representative: pulling set up and approved pulling plan, pulling operation.

D. Cable Terminating: Protect terminations of insulated power cables from accidental contact, deterioration of coverings and moisture by the use of terminating devices and materials. Install all terminations of insulated power cables, cable splices, and high voltage terminations in accordance with the manufacturer's requirements. Make terminations using materials and methods as indicated or specified herein or as designated by the written instructions of the cable manufacturer and termination kit manufacturer.

E. Splices in Medium Voltage Cables: Splices shall be made only in pullboxes and only where approved in advance by the Owner. Splices in Shielded Cables: Splices in shielded cables shall include covering the spliced area with metallic tape, or like material, to the original cable shield and by connecting it to the cable shield on each side of the splice. Provide a copper ground connection as part of the splice installation. Wire shall be trained to the sides of the enclosure in a manner to avoid interference with the working area.

F. Cable in Underground Duct:

1. The duct shall have a minimum slope of 3 inches in each 100 feet away from buildings and toward manholes and other necessary drainage points, and shall run in straight lines except where a change of direction is necessary. As each conduit run is completed, a testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the inside diameter of the duct shall be drawn through the duct; after which a brush, having stiff bristles, shall be drawn through until the conduit is clear of all particles of earth, sand or gravel; conduit plugs shall then immediately be installed. Provide a plastic warning tape in the backfill approximately 12 inches below grade. The tape shall be yellow plastic with integral warning legend repeated continuously throughout the entire length of the tape.
2. Except at conduit risers, accomplish changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, by long sweep bends having a minimum radius

of curvature of 25 feet. Sweep bends may be made up of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with conduits of less than 3 inches in diameter, a minimum radius of 36 inches for ducts of 3 inches in diameter and larger, and a minimum of 48 inch radius for medium voltage applications.

3. Use end bells where duct lines enter pullboxes or handholes and rigid steel exposed in pullboxes or handholes. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand and dirt by means of suitable conduit plugs.
4. Removal of Ducts: Where duct lines are removed from existing manholes, close the openings to waterproof the manhole. Chip out the wall opening to provide a key for the new section of wall.
5. Multiple duct runs shall maintain 3-inch minimum separation between runs. Provide plastic spacers at maximum 5 feet-0 inch centers to maintain 3 inch spacing between conduits. Drive two reinforcing bars to anchor the conduits at 10 feet-0 inch centers to prevent floating during concrete pour.
6. Do not install plastic conduit in rock base. Provide double wrapped galvanized rigid steel elbows on runs greater than 100 feet or on runs with more than two 90-degree elbows.
7. Install 3” minimum concrete encasement on duct banks that include two or more raceways in a single trench. Drive two reinforcing bars to anchor the conduits at 10 feet-0 inch centers to prevent floating during concrete pour.
8. Burial depth - Concrete encased: 30-inch minimum for 600V or lower systems to top of concrete encasement.
9. Color mix on medium voltage ductbanks to be 10-lbs red oxide per yard of concrete.
10. Manholes shall be left in a clean condition with all debris removed and with all cables supported on approved cable supports. All stubs for manholes shall be concrete encased and shall extend 5 inches beyond manholes.
11. Underground Structures: Precast concrete - risers and tops to conform to ASTM C 478. Precast units (ACI 318) shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete pullboxes. Pullboxes shall be the type noted on the drawings. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide all necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. A pulling-in iron shall be installed in the wall opposite each duct line entrance. The words "HIGH VOLTAGE" and “M.H.-XX” (confirm manhole number with Owner) shall be cast in, or welded on, the top of pullbox cover - see drawings for details. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable. All steel covers, frames, and steel fittings shall be galvanized. Penthead security bolts shall secure steel cover.
    a. Metal Frames, Covers and Gratings: Full traffic covers shall satisfy the ASSHTO H-20 loading criteria, and pedestrian traffic covers shall satisfy the ASSHTO H-10 loading criteria.
    b. Drainage Pipe and Fittings: Cast-iron, extra strength. Drains shall be cast-iron, coated or uncoated, plain pattern, bottom outlet with perforated or slotted hinged cover.

G. Transformer or Concrete Pullbox Grounding: See Section 26 24 00. Install ground rod in manholes and in transformer compartment, and connect properly to the cable shielding, metallic sheath, and armor at each cable joint or splice by means of braided tinned copper

wire. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations.

3.2 LABELING

A. Label medium voltage conductors, splices, and terminations as per Section 26 05 00 and as detailed on Drawings.

3.3 SERVICES INSTALLATION

A. Electric Service: Arrange with the Owner for scheduling of splicing into existing medium voltage site distribution system where indicated on the drawings. Furnish and install all materials and labor necessary for complete installation as noted on drawings, and as required by the Owner.

3.4 EARTHWORK

A. See Section 262700.

3.5 TESTING

A. Perform inspection and tests per NETA ATS-2017 Section "Cables-Medium Voltage-69kV Maximum" and per Owner's requirements.

B. All medium voltage cables, cable splices, junctions and jumpers shall be subjected to dielectric-absorption and high voltage test after the installation has been completed.

C. Provide schedule notification to the Owner 5 working day prior to testing.

D. Each medium voltage power cable shall be tested with a 2,500 volt insulation resistance test set and readings recorded each 15 seconds for the first 3 minutes until fully charged and then at 1 minute intervals for 3 minutes with a minimum reading of 200 megohms at 60° F and corrected accordingly at all other temperatures.

E. For each medium voltage cable: An initial voltage shall be applied and increased in no less than 5 uniform steps up to the maximum test voltage for 15 KV system to 63 KVDC and hold for 5 minutes.

F. Ensure that terminator voltage limits are not exceeded. Investigate any readings exceeding 10 micro-amps for every 1,000 feet of cable.

G. Perform a shield continuity test on each power conductor by ohmmeter method. Contractor to investigate resistance values in excess 10 ohms per 1,000 feet of cable.

H. All cables failing tests or with evidence of damage shall be removed and replaced in their entirety (no splices), at no cost to the Owner.

I. Contractor shall assist in testing by providing test equipment, labor and technical personnel.

J. Contractor to provide equipment that will allow for proper bailing to avoid premature connection failure.

K. Test Fault Indicators and verify correct operation per Manufacturer's instructions.

L. See Section 26 08 00 for additional requirements.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260573
PROTECTION & COORDINATION STUDIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Short-circuit analysis.

B. Protective device evaluation.

C. Coordination study.

D. Arc Flash study.

1.2 REFERENCE STANDARDS

A. IEEE 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems; 2001.

B. IEEE 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis; 1997.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements

1.3 QUALITY ASSURANCE

A. Study Preparer Qualifications: Electrical testing agency regularly engaged in arc flash, short circuit, and coordination studies, with at least 5 years experience in work of this type, and employing professional electrical engineers licensed in the State in which the Project is located to perform the studies.

B. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
   1. SKM Systems Analysis
   2. Operation Technology, ETAP
   3. Power Analytics Corporation

C. Contractor Responsibility: Provide all project-related data needed by study preparer, including equipment, wire sizes, insulation types, conduit types, and actual circuit lengths.

D. Owner's Responsibility: Provide data on relevant Owner power distribution equipment.

1.4 PROTECTIVE DEVICES

A. Provide protective devices of ratings and settings as required so that the protective device closest to the fault will open first.

B. In addition to requirements specified elsewhere, provide overcurrent protective devices having ratings and settings in accordance with results of this analysis.

PART 2 - PRODUCTS

2.1 SHORT-CIRCUIT ANALYSIS, PROTECTIVE DEVICE EVALUATION, COORDINATION, AND ARC FLASH STUDY

A. Scope of Services: Provide a current and complete short-circuit study, equipment interrupting or withstand evaluation, protective device coordination, and arc flash evaluation study for the electrical distribution system..
   1. Study shall include all portions of electrical distribution system. Normal and emergency system connections and those which result in maximum fault conditions shall be adequately covered in the study.
   2. The study shall be performed by Emerson Network Power, or equal. Study shall be prepared and signed by a California registered Electrical Engineer.
   3. In the case of additions or modifications to existing distribution systems, the scope of the Study shall include all new portions of the distribution system, and all existing devices upstream of the distribution system modifications all the way to the facility main service switchboard.

B. Submittals:
   1. Submit Study to Architect for review prior to receiving final acceptance of distribution equipment shop drawings or prior to release of equipment for manufacture. If formal completion of Study may cause delay in equipment manufacture, acceptance from Architect may be obtained for preliminary submittal of sufficient study data to ensure that selection of device ratings and characteristics will be satisfactory.

C. Short-Circuit Study:
   1. The study shall be in accordance with applicable ANSI and IEEE Standards.
   2. The study input data shall include the utility company’s primary short-circuit single-and three-phase contribution, with the X/R ratio, the resistance and reactance components of each branch impedance, motor and generator contributions, base quantities selected, and all other applicable circuit parameters.
   3. Short-circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at each switchgear bus, switchboard, distribution switchboard, panelboard, and other significant locations through the system.

D. Equipment Evaluation Study:
   1. An equipment evaluation study shall be performed to determine the adequacy of circuit breakers, controllers, surge arresters, switches, and fuses by tabulating and comparing the short-circuit ratings of these devices with the available fault currents. Any problem areas or inadequacies in the equipment shall be promptly brought to the Architect's attention.

E. Protective Device Coordination Study:
   1. A protective device coordination study shall be performed to select or to check the selections of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated voltage and current transformers, and low-voltage breaker and fuse trip characteristics and settings.
   2. The coordination study shall include all voltage classes of equipment and protective devices. The phase and ground overcurrent protection shall be included, as well as settings for all other adjustable protective devices.
   3. The time-current characteristics of the specified protective devices shall be plotted on appropriate log-log paper. The plots shall include complete titles, representative one-line diagram and legends, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low-voltage circuit breaker trip curves, relay curves and fuse curves. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, ANSI

transformer magnetizing inrush and withstand curves per ANSI C37.91, cable damage curves, symmetrical and asymmetrical fault currents. All requirements of the current National Electrical Code shall be adhered to. Reasonable coordination intervals and separation of characteristics curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a complete system basis. Sufficient curves shall be used to clearly indicate the coordination achieved to each main breaker or fused device, each feeder breaker, and each primary protective device.

4. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios, manufacturer, type, range of adjustment, and recommended settings. A tabulation of the recommended power fuse selection shall be provided for all fuses in the system. Discrepancies, problem areas, or inadequacies shall be promptly brought to the Architect's attention.

F. Arc Flash Evaluation Study:
   1. An arc flash evaluation study shall be performed to determine, in coordination with the Owner's safety policy, the required personal protective equipment (PPE) when working on energized equipment.
   2. The arc flash evaluation study shall comply with all NFPA 70E and OSHA requirements for calculating and identifying incident energy levels and the corresponding PPE that would be required in each instance.
   3. The calculated incident energy levels and recommended PPE for each location shall be summarized in a tabulated form listing location, circuit identification, and PPE. Discrepancies, problem areas, or inadequacies shall be promptly brought to the Architect's attention.
   4. Arc flash calculations shall be based on values of fault current magnitudes identified in the short-circuit analysis and the associated clearing times of the over current protective devices determined by the coordination study. The settings recommended by the coordination study shall be the basis of arc flash calculations.
   5. Calculation methods shall comply with IEEE Standard 1584 "IEEE Guide for Performing Arc-Flash Hazard Calculations".
   6. Per IEEE Standard 1584, a maximum arc time of two seconds shall be utilized to limit incident energy values.
   7. Recommended settings of all protective equipment based on the short circuit and equipment coordination study shall be implemented prior to attaching arc flash hazard labels to the equipment.
   8. All electrical equipment shall be field marked to indicate where a flash hazard exists in compliance with NEC 110-116. Labels shall be submitted for approval prior to application. Labels shall be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

G. Study Report:
   1. The results of the power system study shall be summarized in a final report. Five (5) bound copies of the final report shall be submitted to the Architect.
   2. The report shall include the following sections:
      a. Description, purpose, basis, written scope, and a single-line diagram of the portion of the power system which is included within the scope of study.
      b. Tabulations of circuit breaker, fuse, and other equipment ratings versus calculated short-circuit duties, and commentary regarding same.
      c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
      d. Fault current tabulations including a definition of terms and a guide for interpretation.
      e. Tabulation of appropriate tap settings for relay seal-in units.
      f. Tabulation of arc flash study incident energy levels and PPE requirements.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide the services of a qualified field engineer and necessary tools and equipment to test, calibrate, and adjust the installed protective devices to conform to requirements determined by the coordination analysis.

B. Adjust installed protective devices (including existing upstream devices in the case of modifications or additions to an existing distribution system) having adjustable settings to conform to requirements determined by the coordination analysis.

C. Submit report showing final adjusted settings of all protective devices.

END OF SECTION

SECTION 260800
TESTING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work Included in This Section: All materials, labor, equipment, services, and incidentals necessary to perform the testing and inspection of the electrical work, including but not limited to the general systems noted below:
   1. Grounding system.
   2. Lighting system.
   3. Distribution system.
   4. Lighting control system.
   5. Title 24 Acceptance Testing.

B. Test additional work where specified in other Sections of these specifications or where indicated on the drawings (provide all materials, labor, equipment, services, and incidentals necessary to perform the testing and inspection of this Electrical Work):
   1. Medium voltage switchgear, transformers, and distribution system.
   2. Emergency Generator and Automatic Transfer Switches.

C. Any other electrical work as might reasonably be implied as required, even though not specifically mentioned herein or shown on the drawings.

D. All work shall comply with Sections 260500 and 262700.

E. In addition to the general system tests and inspections indicated above, the Contractor shall perform the following inspections and tests. The Contractor shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections:
   1. System Grounding.
   2. Switchgear, Switchboards, Distribution Panels, Panelboards.
   3. Feeders.

E. In addition to the general system tests and inspections indicated above, the Contractor shall retain the services of a recognized corporately and financially independent testing firm (Emerson Network Power or equal) for the purpose of performing the following inspections and tests. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections:
   1. System Grounding.
   2. Switchgear, Switchboards, Distribution Panels, Panelboards.
   3. Feeders.

E. The purpose of these tests is to assure that all tested electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

1.2 APPLICABLE CODES, STANDARDS, AND REFERENCES

A. All inspections and tests shall be in accordance with the International Electrical Testing Association - Acceptance Testing Specifications ATS-2017 (referred to herein as NETA ATS-2017).

1.3 QUALIFICATIONS

A. Qualifications of the Testing Firm shall be as listed in NETA ATS-2017.

PART 2 - PRODUCTS

2.1 THIS ARTICLE DOES NOT APPLY TO TESTING.

PART 3 - EXECUTION

3.1 GENERAL

A. Final test and inspection to be conducted in presence of the Authority having Jurisdiction (AHJ) or Inspector of Record (IOR). Test shall be conducted at the expense of, and managed by, the Contractor, at a mutually agreed time. Submit written test report of all tests, with test result values and overall outcome.

B. All portions of the electrical installation shall be inspected and tested to ensure safety to building occupants, operating personnel, conformity to code authorities and Contract Documents, and for proper system operation.

3.2 INSPECTIONS AND TESTS

A. Tests: Field tests shall be performed and reports submitted, as per Section 260500, Part 1.
   1. Final Inspection Certificates: Prior to final payment approval, deliver to the Owner, with a copy to the Architect, signed certificates of final inspection by the appropriate local authority having jurisdiction.

B. Grounding System:
   1. All ground connections shall be checked and the entire system shall be checked for continuity. The resistance of grounding electrodes in the system shall be measured using a 3 point fall-of-potential method. The maximum ground resistance shall be three ohms. If the measured ground resistance exceeds three ohms, install (1) additional ground rod, bonded and interconnected with the grounding electrode system.
   2. Ground tests shall meet or exceed the requirements of the National Electric Code.

C. Lighting Systems:
   1. The interior and exterior lighting systems shall be checked for proper local controls and operation of entire installation, including the operation of the low voltage lighting control system.

D. Power Distribution System:
   1. Test main switchboard, distribution boards, panel boards, and transformers for grounds and shorts with mains disconnected from feeders, branch circuits connected and circuit breakers closed, all fixtures in place and permanently connected and grounding jumper to neutral lifted and with all wall switches closed.
   2. Test each individual circuit at each panelboard with equipment connected for proper operation. Inspect the interior of each panel.
   3. Check verification of color coding, tagging, numbering, and splice make-up.
   4. Verify that all conductors associated with each circuit are in same conduit.
   5. Demonstrate that all lights, jacks, switches, outlets, and equipment operate satisfactorily and as called for.
   6. Test proper functioning of the ground fault protective system(s).

7. Perform megger tests of all distribution system feeders prior to energizing. All Cables failing megger tests or with evidence of damage shall be removed and replaced in their entirety (no splices), at no cost to the Owner. Damaged cables may not be field repaired without specific approval of the Architect.

E. Lighting Control System: Verify that all equipment, components, and devices function as specified. Refer to Section 265700 for additional testing requirements.

F. Where the following systems are specified herein and/or indicated on the drawings, verify that all equipment, components, and devices function as specified and meet all additional testing as described in related individual Sections of this specification:
   1. Medium voltage switchgear, transformers, and distribution system.
   2. Emergency Generator and Automatic Transfer Switches.

J. Title 24 Acceptance Testing: Contractor shall complete the requirements for Title 24 Acceptance Testing, as per CA Title 24, Part 6.
   1. Perform testing requirements as per Title 24 Lighting Acceptance requirements. Testing shall include construction inspection of installed controls, occupancy / motion sensor testing, manual daylighting controls testing, automatic time switch controls testing, and demand response system interface, as applicable.
   2. Complete and submit all required forms for complete Acceptance Testing.
   3. Obtain required review and approval of Acceptance Forms to allow final certificate of occupancy to be granted.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 261202

THREE-PHASE PADMOUNTED TRANSFORMER

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American National Standards Institute (ANSI) Publications:

C2	National Electric Safety Code
C57.12.26	Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, Separable Insulated High Voltage Connectors; High Voltage 24,940 GRDY/14400 Volts and below; 2500 kVA and Smaller
Z35.1	Specifications for Accident Prevention Signs

C. American Society for Testing and Materials (ASTM) Publications (Latest Edition):

D 92	Test Method for Flash and Fire Points by Cleveland Open Cup
D 117	Test Method for Electrical Insulating Oils of Petroleum Origin
D 877	Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
D 3487	Mineral Insulating Oil Used in Electrical Apparatus, Standard Specification

D. Institute of Electrical and Electronic Engineers, Inc. (IEEE) Publication (Latest Edition):

386	Separable Insulated Connectors for Power Distribution Systems Above 600 V

E. National Fire Protection Association (NFPA) Publication (Latest Edition):

70	National Electrical Code

F. Nema 210.

1.2 SUBMITTALS

A. Catalog Information and Shop Drawings: Indicate ratings, capacity, and detailed arrangement of components.
1. Distribution Transformer
2. Primary Fuses
3. Primary Oil-Immersed Switches

B. Certificates:
1. Certified Test Report of Transformer Manufacturer
2. Provide CBC 2019 compliant seismic installation. See Section 260500 for all certification and submittal requirements.

C. Equipment bushings, dead-end plugs, dead break junctions and grounding connectors shall be submitted to and approved by the Architect before ordering.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Distribution Padmount Compartmental-Type Transformer: The unit shall be suitable for loop connection and shall contain the transformer, six 200A universal bushing wells, three two position rotary oil-immersed load break - load make switches including an A and a B loop switch and a transformer winding switch, primary current limiting fusing, and primary overload fusing in a weather resistant, tamper-resistant enclosure, arranged for padlocking, with a full tank and compartment weather cover. Transformer shall conform to ANSI C57.12.26. High voltage and low voltage compartments shall be isolated from each other in a manner to require a separate unlatching or unbolting action to give access to the high voltage compartment. (Note: provide radial connection where indicated on the drawings).

B. Transformer shall conform to Owner's Standards, including testing and adjustment requirements.

C. Transformer: Dead front, three phase, two winding, 60 Hz, 65 degree C rise, oil insulated, self-cooled type rated as indicated on the drawings, with two 2-1/2% full capacity taps above and below rated primary voltage. Basic Insulation Level shall be 125 kV on the primary side, and 30 kV minimum on the secondary side. High voltage winding shall be 12.47 kV delta (or 12.00 kV where indicated on the drawings). Low voltage shall be 277/480 V grounded wye, 4-wire. Windings shall be copper. Transformer tank shall be sealed except for bolted handhole access. Provide lifting lugs. Provide external tap changing for de-energized operation only. Locate the changer control handle within the high voltage compartment and provide position indicator and method of securing the control handle against unintentional operation. Switch indicating plate shall be readable from 5 feet away. Tank Construction: Liquid immersed transformer shall have a totally bolted gasketed cover with a weather cover over the compartment and over the tank.

D. The transformer tank and compartment shall be assembled as an integral unit for mounting on a pad. There shall be no exposed screws, bolts, or other fastening devices, which are externally removable. There shall be no openings through which foreign objects such as sticks, rods, or wires might contact live parts. The construction shall limit the entry of water (other than flood water) into the compartment so as not to impair the operation of the transformer.

E. Full-height, air-filled high voltage and low voltage terminal compartments with full-height and full-width hinged door for each compartment shall be located side-by-side separated by a steel barrier, with the high voltage compartment on the left (as viewed from the front of the transformer). To facilitate making connections and permit cable pulling, the doors and compartment hood shall be removable. Removable doorsill on compartments shall be provided to permit rolling or skidding of unit into place over conduit studs in foundation.

F. Mineral Oil: ASTM D 3487, Type II tested in accordance with ASTM D 117.

G. Transformer: Provide the accessories listed below:
   1. Bronze drain and sampling valve: 1-inch trade size minimum, with FPT plugged discharge
   2. Filter press connections

3. Ground pads
4. Provision for lifting and jacking
5. Top liquid dial-type thermometer without alarm contacts
6. Pressure-vacuum gauge
7. Pressure-relief device
8. Oil fill connection: Capped, 1.25-inch trade size minimum
9. Oil level gauge: With normal level at full load rated temperature rise indicated
10. Oil temperature gauge: Calibrated in degrees C, with full load temperature rise indicated
11. 4 extra hold down pads compliant with CBC 2019 seismic requirements

H. High-voltage switches: Provide internal, oil-immersed rotary, gang-operated, load break - load make switches. Minimum switch rating shall be load-break and make, 200A continuous; make and latch 10,000A symmetrical; 6,000A minimum for 1 second.

I. Primary Fusing:
1. Internal Fault Protection: Provide current limiting fusing in dry well, air-insulated, with non-load break fuse holders inserted in the transformer tank. Provide an integral warning notice and safety baffle to prevent fuse removal unless the transformer is de-energized. Fuse values shall be 150 percent of full load current and fuses shall be Class E.
2. "Weak-link" primary fusing is not acceptable in lieu of current limiting primary fusing.
3. Overload Protection: Expulsion fuses, dead front Bay-O-Net type.
4. Provide a spare set of (3) fuses of each type in original cartons.

J. A-B Loop Switches: Provide primary loop switches (both switches normally closed, to maintain loop).

K. Enclosure: Enclosure shall be constructed in accordance with ANSI C57.12.26.

L. Finish - Prior to prime coating, all welds shall be ground smooth. Rust inhibiting prime coat over cleaned and degreased surfaces. Vinyl paint for finish coat on all surfaces. Color shall be Munsell No. 7GY3.29/1.5 Green.

M. Latches - Three Point Vault Style, chromium plated with 4-inch handle and provisions for padlocking.

N. Grounding Pads - Steel ground pad welded to tank wall in primary and secondary compartment. Each pad drilled and tapped for two 3/8 inch (min.) steel bolts.

O. Termination compartment dimensions shall be as follows:
1. Height: Maximum of 66 inches or the transformer height plus 2 inches (approx.)
2. Depth: 18 inches minimum, 24 inches maximum.
3. Width: Primary Compartment 42 inches min.; Secondary Compartment 24 inches min.

P. The nameplate shall comply with ANSI C57.12.26 except that the number of gallons of coolant shall be shown.

Q. Transformer shall be as manufactured by Eaton-Cutler Hammer, Schneider-Square D, ABB, Cooper, or approved equal.

R. High Voltage Separable Connectors: Provide well bushings with 15 kV inserts for separable connector terminations – see Section 260513 for connector requirements.

S. Secondary Connections - Spade bushings: National Electrical Manufacturers Association (NEMA) drilled copper terminal, 1.75 inch hole spacing. Provide secondary bus supports using an insulating material to prevent spade from bending due to cable weight. Hi-press lugs only for cable termination.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Padmounted transformer installation shall conform to the Manufacturer's shop drawings and mounting instructions and shall include securing it to a concrete pad by at least four anchor bolts. Completed installation shall conform to the requirements of ANSI C2.

3.2 FIELD TESTS

A. Testing of medium voltage equipment shall be performed in conjunction with the Manufacturer's representative.

B. Coordinate with the factory representative and provide all assistance required in the start-up and testing of the equipment.

C. Perform inspection and tests per NETA ATS-2017 Section “Transformers - Liquid-Filled". Laboratory tests on the insulating fluid for the following items are not required: Specific gravity, power factor, water content, dissolved gas analysis, total combustible gas content. The following tests are not required; winding-resistance tests on each winding in final tap position, percent oxygen tests on the nitrogen gas blanket.

D. Field testing requirements for transformer to include ASTM D877 dielectric liquid test, ASTM D971 interfacial tension test and ASTM D1533 moisture content test.

E. See Section 260800, "TESTING", for additional requirements.

END OF SECTION

SECTION 262400
SERVICE AND DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work Included in This Section: All materials, labor, equipment, services and incidentals necessary to install the electrical work as shown on the drawings and as specified hereinafter, including but not limited to the work listed below.

B. Temporary power for construction.

C. Main switchboard, Distribution Switchboards, Distribution Panels, Transformers, Distribution System, Panel Boards, Grounding, and Overcurrent Protective Devices.

F. All required incidental work, such as excavating, backfilling, testing, and temporary power.

G. Any other electrical work as might reasonably be implied as required, even though not specifically mentioned herein or shown on the drawings.

H. All work shall comply with Sections 260500 and 262700.

1.2 RELATED WORK

A. Division 09 - Finishes

B. Division 23 - Heating, Ventilating, and Air Conditioning

1.3 SUBMITTALS

A. Comply with the provisions of Section 260500 - Submittals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Refer to Section 260500, Part 2 - Products

B. All new equipment shall match existing.

C. List of Equipment Manufacturers:

Switchboards and Motor Control Centers

Eaton-Cutler Hammer, General Electric, Industrial Electric Manufacturing, Schneider-Square D.

Panelboards and Distribution Panel

Same manufacturer as Main Switchboard.

Dry-type Transformers

Eaton-Cutler Hammer, Schneider-Square D, General Electric.

2.2 MATERIALS

A. Provide and install conduits for primary cables by utility company, concrete pad and grounding for utility company transformer, and conduit for secondary service to main switchboard. Comply with all Utility Co. requirements.

B. Furnish and install telecommunications service conduits and pullboxes; install conduits to main point-of-entry backboard as indicated on the drawings. All work shall conform to utility company requirements and to Section 262700.

C. Grounding:
   1. Provide and install grounding system as noted on the drawings.
   2. Grounding electrode conductor: bare stranded copper type, #4/0 minimum.
   3. Install ground wires in rigid conduit.
   4. All grounding electrode conductor connections "thermite" or "cad-weld" welded.
   5. Use approved pressure type solderless connector or use fusion welding for all connections to and bonding of grounding electrode system. All connections shall be visible, readily accessible for testing purposes. Grounding electrode conductor between the grounding electrode and service equipment: Minimum #4/0.
   6. Furnish and install solid copper or copper-clad 5/8" x 10'-0" ground rod(s). Where multiple ground rods are shown, install a minimum of 20'-0" apart. Install ground rods in accessible boxes with covers. Furnish and install 2-#4/0 bare copper cables between multiple ground rods and main switchboard ground bus.
   7. Terminate grounding conduits at equipment with ground bushing, with ground wire connected through bushing.
   8. Provide No. 12 stranded (green) THHN conductor from outlet box to ground screw of every receptacle.
   9. Ground all isolated sections of metallic raceways.
   10. Provide #12 minimum stranded (green) THHN conductor sized per NEC, or as noted, connected continuously throughout branch circuit for all circuits, bonded to panel ground bus, and to all electrical devices and equipment enclosures.
   11. Grounding electrode installed as follows:
      a. Place #4/0 bare copper cable in foundation trench; tensioned, supported in such a manner that it cannot be less than two (2) inches from bottom or side of concrete when foundation concrete is poured; not less than one hundred feet of conductor. Embed in foundation with a loop at approximate center, brought out at top of foundation at location of building service equipment for connection to service equipment and for bonding to other parts of the grounding electrode system.
      b. Use approved pressure type solderless connector or use fusion welding for all connections to grounding electrode. Connection visible, readily accessible for testing purposes. Grounding electrode conductor between the grounding electrode and service equipment: Minimum #4/0.
      c. Connect grounding electrode system to metallic water service entry metallic cold water pipe (if available) with nonferrous clamp and bare copper cable (sized as required) in conduit. Connection shall be accessible for inspection.
      d. Connect grounding electrode system to effectively grounded building steel as indicated on the drawings. Use exothermic weld, connection shall be accessible for inspection.
      e. After installation, test system using the three-point fall of potential method only. Record results and submit to Architect for approval. If resistance to ground exceeds three ohms, install an additional ground rod, bonded and interconnected to the grounding electrode system.
      f. Connect ground bar of separately derived systems (e.g all dry-type transformers) to effectively grounded building steel at the closest possible accessible location, or if

building is concrete, or the steel is not effectively grounded, to the main switchboard ground bus: Use #4/0 copper conductor for all connections.

D. Main Switchboard, Distribution Switchboards, and Distribution Panels:
   1. General: Switchboard shall be group-mounted type, metal enclosure with ground bus and insulated full capacity neutral bus.
   2. Equipment:
      a. The switchboard shall be braced for a short circuit current of 65,000 amps minimum, and for 100,000 amps when indicated on the drawings. Bracing shall be per NEMA and UL standards.
      b. The switchboard shall comply with all the requirements of the Utility Company.
   3. The switchboard shall be pad-mounted, self- supporting, dead-front and rear, front-operated, front-connected, distribution type. Nema 1 (indoor) or Nema 3R (outdoor). The enclosure shall be 90 inches high, made of cold rolled steel on a structural shape, or formed, steel frame and shall be mounted on two 3-inch, 5-pound continuous channel iron sills, which shall be closed at the ends between the two channels.
   4. This contractor is responsible for the complete installation of the switchboard within the space provided (both vertical and horizontal) and shall verify and/or coordinate all dimensions prior to ordering equipment. Proper allowances should be included to allow complete installation and erection.
   5. The switchboard shall be a minimum of 24 inches deep and shall be constructed of National Electrical Code (NEC) gauge steel.
   6. For all switchboards or distribution panels rated 1,200 Amps or higher, provide an arc energy reduction measure in compliance with NEC 240.87(B), to reduce arc clearing time.
   7. The switchboard shall be provided with a cable pull section at the top of the switchboard. Provide a minimum 12 inches of vertical clearance between the cable terminal lugs bolted to the switchboard busses and the top and bottom of the switchboard enclosure. Horizontal pull sections and gutters shall be kept free and clear of busses. Where busses cross vertical pull sections, the busses shall be insulated.
   8. All connections between bus bars shall be of a bolted type using Belleville washers. Clamps will not be accepted. All bus bars shall be accurately formed, and all holes shall be made in a manner which will permit bus bars and connections to be fitted into place without being forced.
   9. The design of all current-carrying devices or parts of the switchboard shall conform to the standard specified in the related sections of Underwriters' Laboratories, Inc. (UL) No. UL-891 and National Electric Manufacturer's Association (NEMA) Standard PB-2, except as these characteristics may be modified herein.
   10. Bus bars, connection bars and wiring on the back of the switchboard shall be arranged so that maximum accessibility is provided for cable connections from the front.
   11. Ampere ratings for rectangular bus bars shall be in accordance with the temperature rise standard of National Electric Manufacturer's Association (NEMA) and the Underwriters' Laboratories, Inc. (UL).
   12. The enclosure shall be chemically cleaned by parkerizing, bonderizing or phoshorizing as a unit after all welding has been completed. The enclosure shall then be painted with a rust- resisting primer coat of paint and shall be finished with a coat of light gray, baked enamel.
   13. Each section shall be bussed for the full connected load of that section. Extend bussing to spare circuit breaker "Spaces." Drill busses for future circuit breakers, and provide breaker connector hardware where indicated on the drawings or where required for ready installation of future circuit breakers.
   14. Provide copper bus bars and connections with silver-plated contact surfaces.
   15. The contact surfaces and studs of all devices to which bus connections are made shall also have silver-plated surfaces.

16. Locate ground bus, with a cross-section equal to at least 25 percent of the capacity of the main bus rating, in the back of the switchboard and extend bus throughout the length of the switchboard assembly. Ground each housing of the assembly directly to this bus.
18. Rigidly support all bus and connection bars and current transformers.
19. Fit all nuts and connections with locking devices to prevent loosening.
20. Provide load connections with solderless lugs. Factory-install all devices shown on Drawings as specified herein.
21. Provide ground fault protection for all main breakers or feeder breakers rated at 1000A or higher at 277/480V 3PH, and when otherwise indicated on the single line diagram or where otherwise noted on the drawings. Protection shall consist of a current sensor, relaying device, and the appropriately sized overcurrent protection device.
22. Provide a bonding strap from the equipment ground bus to the neutral bus.
24. Provide transient voltage surge protection, integral to or adjacent to the switchboard when indicated on the plans or where otherwise noted in the specifications herein. Refer to Section 26 43 00.
25. Distribution Panels shall comply with all relevant requirements of the above paragraphs - minimum 12" deep, for floor or wall-mounting.

E. Panelboards:
1. Surface (or flush where indicated on the drawings) mounted, with branch circuits as indicated on the drawings.
2. Enclosures: code gauge galvanized sheet steel with welded full flange end pieces, stretcher- leveled steel trim, backpan and door.
3. Bussing of copper with silver-plated contact surfaces.
4. Trims on surface-mounted cabinets secured with nickel-plated screws with cup washers, bottom of all trims to have lugs for resting on cabinet flange.
7. Panels shall be 20 inches minimum in width, provided with approved gutter space, barriers and adjustable supports. Doors mounted with concealed hinges provided with combination spring latch and lock. Doors and trims and surface mounted cabinets primed and finished with one coat baked on gray enamel. All visible panel enclosures and covers in finished (occupied) areas shall be painted to match adjacent wall finish.
8. Breakers on same phase to be aligned horizontally. Each panel provided with quantity (5) spare handle locks. Install handle locks on all breakers serving fire alarm equipment.
9. Each branch circuit of panelboards to have a permanently fixed number with one word directory, mounted under celluloid on inside of cabinet door, showing circuit numbers and typewritten description of outlets controlled by breakers. Color code mains and each breaker terminal, same as conductor insulation.
10. Each panel shall be equipped with a copper ground bus.
11. All panels shall be fully bussed to accept future circuit breakers, with breaker hardware provided where indicated on the drawings.
12. Panel board submittals shall include diagrams of the circuit breaker arrangements in the panels. Arrange circuit breakers in panels exactly as shown on the panel schedules in the construction documents - no deviations permitted.

F. Circuit Breakers:
1. General: Circuit breakers shall be molded case rated for 480 or 240 volts, multiple or single pole and amperage rating as shown on the drawings, bolt on, manually operated with "de-ion" arc chutes.
2. For all circuit breakers rated 1,200 Amps or higher, provide an arc energy reduction measure in compliance with NEC 240.87(B), to reduce arc clearing time.
3. Main circuit breaker shall be shall be rated to interrupt the available short circuit current - 65,000 amps RMS unless otherwise indicated on the drawings.
4. Distribution circuit breakers shall be rated for the amps interrupting capacity noted on the drawings or U.L. series rated with the main circuit breaker.

5. Branch circuit breakers shall be rated for the amps interrupting capacity or U.L. series rated with the distribution and main circuit breakers, General Electric type THQB or equal, minimum 10,000 A.I.C for 120/208 volt; type TEY or equal, minimum 14,000 A.I.C for 277/480 volt.
6. Branch breakers feeding dwelling unit Bedroom 15 and 20 Amp branch circuits shall be arc-fault circuit-interrupting type (per NEC 210-12).

G. Dry-Type Transformers:
1. Ventilated type.
2. Dry-type general distribution transformers shall meet the California Title 24 requirements for energy efficiency standards and DOE 10 - CFR, Part 431 (2016) for energy efficient transformers.
3. Transformer shall be 3 phase, 60 Hertz. Primary winding shall be Delta connected and secondary winding shall be Wye connected. The temperature rise at rated voltage and full load shall not exceed 150 degrees C with a 220 degrees C U.L. Component Recognized Insulation System. The windings shall be aluminum or copper.
4. The higher voltage winding shall have quantity (6) 2.5% taps - (2) FCAN and (4) FCBN. Set secondary voltage for 120/208V.
5. Transformer terminals shall be front connected for ease of installation and maintenance.
6. Where the transformers are installed outdoors provide weatherproof drip cover, rodent screen and a weathertight rating of the enclosure.

H. 'K' Type Transformers:
1. The transformers shall be marked with a label stating "Suitable for Non-Sinusoidal Current Load with K Factor of 13 (or higher where indicated on the drawings) per UL Guide Specifications.
2. Transformers shall be 3 phase, 60 Hertz. Primary winding shall be Delta connected and secondary winding shall be Wye connected. The temperature rise at rated voltage and full load shall not exceed 150 degrees C with a 220 degrees C U.L. Component Recognized Insulation System. The windings shall be aluminum or copper.
3. The higher voltage winding shall have quantity (6) 2.5% taps - (2) FCAN and (4) FCBN. Set secondary voltage for 120/208V.
4. A copper electrostatic shield shall be inserted between the primary and secondary windings. The primary and secondary conductors shall all be individually insulated, as small in size as possible, and transposed where necessary to keep eddy current losses at an absolute minimum. The primary winding conductor shall be of sufficient size to limit the temperature rise to its rated value even with the circulating 3rd harmonic current. The secondary neutral shall be twice the ampacity of the secondary phase conductors. The Basic Impulse Level of all windings shall be 10 KV. The core flux density shall be well below the saturation point to prevent core saturation caused by the harmonics even with a 10% primary overvoltage.
5. Transformer terminals shall be front connected for ease of installation and maintenance.
6. Transformers shall meet DOE 10 - CFR, Part 431 (2016) for energy efficient transformers.

I. Magnetic starters: shall be rated in accordance with latest published NEMA standards for size and horsepower rating, Eaton-Cutler Hammer A-200 series or equal. Provide with overload sensor in each phase, hand-off-auto switch, red "run" pilotlight, in NEMA 1, NEMA 4X, or NEMA 3R enclosure or in motor control center where indicated. Coil shall be rated 120 VAC. Starters shall be across-the-line nonreversing unless otherwise noted.
1. Contacts: Across-the-line magnetic starters shall be equipped with double break silver alloy contacts. All contacts shall be replaceable without removing power wiring or removing starter from panel. The starter must have straight-through wiring.
2. Coils: Coils shall be of molded construction. All coils shall be replaceable from the front without removing the starter from the panel.

3. Overload Relays and Thermal Units: Overload relays shall be the melting alloy type with a replaceable control circuit module. Thermal units shall be of one-piece construction and interchangeable. The starter shall be inoperative if the thermal unit is removed.

PART 3 - EXECUTION

3.1 REFER TO SECTION 260500 FOR DETAILS OF WORK UNDER THIS SECTION.

3.2 INSTALLATION/APPLICATION/ERECTION

A. Excavate and trench as necessary for the electrical installation, and when the work has been installed, inspected and approved, backfill all excavations with clean earth from excavation, or imported sandy soil in maximum 8" (eight-inch) layers, moisten and machine tamp to 95% compaction, and restore the ground and/or paving or floor surfaces to their original condition.

B. Switchboards and Distribution Panels Installation: Mount as detailed on the drawings.

C. Motor Connections:
   1. Install motor circuits complete for all motors by other trades
   2. Furnish and install all disconnect switches, outlet boxes, etc., as required by code.
   3. All motor and temperature control low voltage wiring shall be installed and connected by Division 23 Section of specifications, unless otherwise indicated on electrical drawings.

D. Motor Starters Installation:
   1. Deliver starters to site without thermal overload elements. Determine nameplate rating of each motor, after motor and starter installation, select thermal element rating from measured motor running current and install proper elements in starters.
      a. Submit chart denoting motor designation, motor H.P., motor running current (N.P.), actual running current fuse/breaker size and thermal element catalog number. Take readings of motor running currents in conjunction with Division 23 - Heating, Ventilating, and Air Conditioning.

3.3 TESTS

A. Testing and Inspection: See Section 260800 - Testing.

END OF SECTION

SECTION 262700
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work included in this Section: All materials, labor, equipment, services, and incidentals necessary to install the electrical work as shown on the drawings and as specified hereinafter, including but not limited to the work listed below:
   1. Raceways, feeders, branch circuit wiring, wiring devices, safety switches and connections to all equipment requiring electric service.

B. Any other electrical work as might reasonably be implied as required, even though not specifically mentioned herein or shown on the drawings.

C. All work shall comply with Section 260500.

1.2 RELATED WORK

A. Division 09 - Finishes

B. Division 23 - Motors and Mechanical Equipment Installation

1.3 SUBMITTALS

A. Comply with the provisions of Section 260500.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Refer to Section 260500, Basic Electrical Requirements, Part 2 - Products.

B. List of Equipment Manufacturers:

Conduit and Conduit Fittings

Allied Tube and Conduit, Wester Tube and Conduit, LTV Steel Tubular, National Electric Products, AFC, Republic Steel Corporation, Rome Cable Corporation, United States Steel Corporation, Killark Electric Manufacting Company, Raco, VAW Aluminum Company, Bridgeport, Steel City, Thomas & Betts, Carlon, O.Z. Gedney, Appleton, Regal.

Wire and Cable (600V)

American Wire Company, General Wire and Cable Corporation, Okonite Company, Rome Cable Corporation, Cerrowire, American Insulated Wire, AFC Cable Systems, Essex, Simplex Wire and Cable Company, Southwire.

Solderless Lugs and Grounding Connections

Burndy Engineering Company Inc, O.Z. Gedney Company Inc, Penn Union Electric Corporation, Thomas and Betts Company Inc.

Pull Boxes, Gutters, Special Cabinets

Schneider-Square D Company, Columbia Electric Manufacturing Company, General Electric Company, Eaton Inc.

Outlet Boxes

Appleton Electric Company, Killark Electric Manufacturing Company, Lew Electric Fittings Company, National Electric Products Corporation, Raco, Steel City Electric Company, Carlon, Bowers.

Floor Boxes

Steel City Electric Company, Hubbell Inc, RCI, Walker.

Wiring Devices

Leviton, Arrow-Hart, Cooper, Hubbell, Lutron, Bryant.

Conduit Racks, Hangers

General Electric Company, Killark Electric Manufacturing Company, Caddy, National Electric Products Corporation, Republic Steel Corporation, Rome Cable Corporation, United States Steel Corporation, VAW Aluminum Company, Superstrut, B-Line.

Safety Switches (Disconnect and Fusible)

Schneider-Square D Company, Eaton-Cutler Hammer Inc, General Electric Company.

Fuses

Bussman Manufacturing Company, Chase-Shawmut Company.

Firestopping

3M, Nelson.

2.2 MATERIALS

A. Raceways: Only the raceways specified below shall be utilized on this project. Substitutions shall be pre-approved in writing. All bare conduit ends (stub-ups or stub-outs) shall be provided with bushed ends or manufactured insulated throat connectors:
   1. Rigid Type - hot dip galvanized or sherardized steel, use on all interior and exterior locations, below grade or in concrete slab, and to 18" on either side of structural expansion joints in floor slabs, with completely watertight, threaded fittings throughout. Compression fittings are not acceptable.
      a. All rigid steel conduit couplings and elbows in soil or concrete or under membrane to be ½ lap wrapped with Scotch #50 tape and threaded ends coated with T&B #S.C.40 rust inhibitor prior to installation of couplings.
      b. ½ lap wrap all rigid steel conduit stub-ups from slab or grade to 6" above finished grade level with Scotch #50 tape.
   2. In lieu of rigid steel conduit for power and control raceways and branch circuit conduits in soil or concrete slabs, "Schedule 40" PVC with Schedule 80 PVC conduit elbows and stub-ups may be used with code size (minimum No. 12) ground wire. A “stub-up” is considered to terminate 6" above the finished surface.

a. Schedule 80 PVC conduit shall be used in all concrete footings or foundations and to 18" of either side of footings or foundation walls.
b. Schedule 80 PVC conduit shall be used in all concrete masonry unit (CMU) walls or columns.
c. All conduit runs in concrete floor slabs (where allowed) shall be installed to comply with all applicable CBC and structural codes to maintain the structural integrity of the floor slab. Where conflicts occur, alternate routing shall be provided at no additional cost to the Owner.
d. Where schedule 80 PVC is coupled to schedule 40 or other raceways with differing interior dimensions, each end shall be reamed with a reaming tool to reduce the edge profile for protection of the passing conductors during the pull.

3. Intermediate metal conduit may be used in all exposed interior locations, except that electrical metallic tubing may be used in some locations as noted below. Utilize steel compression type fittings for all exposed conduit runs, unless otherwise noted. Die-cast zinc fittings are unacceptable.
4. Electrical metallic tubing may be used exposed in interior electrical and mechanical rooms, in interior unfinished spaces, and in interior concealed and furred spaces, made up with steel watertight or steel set screw type fittings and couplings. EMT shall not be used in under-building crawl spaces or other areas subject to moisture. Set screws shall have hardened points. Die-cast zinc fittings are unacceptable.
5. Surface mounted rectangular non-metallic dual service raceways; Wiremold #5400 (Ivory) or equal with all required compatible activation covers, bezels, inserts, and blank plates for a complete installation. Refer to drawings for outlet quantities in raceway and feed points. All raceway fed flush from rear with horizontal j-boxes, unless otherwise noted.
6. Flexible conduit shall be used in the following instances:
   a. For all motor, transformer and recessed fixture connections, minimum ½"; "Seal tite" type used outdoors and in all wet locations, provide with code size (minimum No. 12) bare ground wire in all flexible conduit.
   b. Where existing conditions preclude the installation of EMT in existing walls to remain, provide and install cut-in type boxes and "fish" flexible MC or flexible conduit and wire through existing walls to remain, unless shown otherwise on plans.
   c. With the exception of the above, flexible conduit shall not otherwise be used on this project.

7. All conduit cuts (factory or field cut) shall be perfectly square to the length of the conduit and cut ends shall be reamed with a reaming tool to provide a smooth edge to the passing conductors and to remove all burs and scrapes. Use of a hand file is not acceptable.
8. All electrical raceways shall be installed concealed, unless otherwise noted. Cut and patch to facilitate such installation to match adjacent and original finish. All exposed conduits, where required, shall be installed parallel to building members.
9. All emergency source circuits shall be installed in separate raceways (from normal power), per 2017 NEC 700.10(B), or the applicable code at the time of permitting.
10. Fasten conduits securely to boxes with locknuts and bushings to provide good electrical continuity.
11. Provide chrome escutcheon plates at all exposed wall, ceiling and floor conduit penetrations.
12. Support individual suspended conduits with heavy malleable strap or rod hangers; supports for ½ inch or 3/4 inch conduit placed on maximum 7-foot centers; maximum 10-foot centers on conduits 1 inch or larger.
13. Support multiple conduit runs from Kindorf B907 channels with C-105 and C-106 straps.
14. Conduit bends - long radius.
15. Flash conduits through roof, using approved roof jack; coordinate with General Contractor.
16. To facilitate pulling of feeder conductors, install junction boxes as shown or required.

17. All empty conduits on the project shall be provided with a nylon pull rope to allow pulling of future conductors intended for the specific raceway. Provide plastic wire-tie style nameplate tags on each end of pull rope with printed identification of conduit use and the location of the opposite end of the rope. Pull ropes for telecommunications service conduits shall meet the utility company requirements.
18. Where conduits pass through structural expansion joints in floor slab, rigid galvanized conduit shall be used 18" on either side of joint, complete with Appleton expansion couplings and bonding jumpers, or equal. All above grade expansion joint crossings shall also utilize expansion joint couplings or flex conduit transitions as required for each particular installation. Installed condition shall allow for a minimum deflection of raceway and wire (in any direction) equal to the structural expansion joint dimension (building to building). No solid conduits shall be allowed to cross expansion joints without proper provisions for building and seismic movement.
19. Minimum cover of conduits in ground outside of building - 36 inches, unless otherwise noted.
20. Provide and install exterior wall conduit seals and cable seals in the locations listed below. Coordinate installation and scheduling with other trades:
    a. Conduit seals through exterior wall or slab (below grade): O.Z. Gedney series “FSK" in new cast in concrete locations, series "CSM" in cored locations.
    b. Conduit seals through exterior wall or slab (above grade): O.Z. Gedney series "CSMI."
    c. Cable seals at first interior conduit termination after entry through exterior wall or slab: O.Z. Gedney series "CSBI." Coordinate quantity of conductors at each location.

B. Outlet Boxes and Junction Boxes. Verify all backbox requirements with devices to be installed prior to rough-in.
1. One piece steel knockout type drawn boxes, unless otherwise noted, sized as required for conditions at each outlet or as noted.
2. Flush-mounted boxes equipped with galvanized steel raised covers for device mounting flush with finished surface. Provide extension rings as required on all acoustical or additional wall treatment areas to bring top of cover flush with finished surface (coordinate with architectural drawings). Devices shall be capable of being tightly mounted to boxes without distorting or bending device or mounting hardware.
3. Boxes for fixture outlets: 4-inch octagon or larger as required, or as noted.
4. Switch and receptacle outlets - not smaller than 4-inch-square in furred walls, with raised cover for single device; ganged where required.
5. Outlet and switch boxes for wet locations, cast aluminum FS or FD type with cast aluminum gasketed spring lid cover. Weatherproof “Bell” type boxes are not acceptable.
6. All connectors from conduit to junction or outlet boxes shall have insulated throats. Connectors shall be manufactured with insulated throats as integral part. Insertable insulated throats are unacceptable.
7. Outlet boxes for telecommunications, 4" square or larger as required or noted, multi-ganged for voice, data, and other services where indicated on the drawings.
8. Conduit Bodies: Malleable iron type, with lubricated spring steel clips over edge of conduit body, O-Z/Gedney type EW, or equal.
9. Floor Boxes:
    a. Classification and Use: Floor boxes shall have been examined and tested by Underwriters Laboratories Inc. to meet UL514A and Canadian Standard C22.2 and shall bear the appropriate label. Floor boxes shall conform to the standard set in the National Electrical Code. Multi-compartment boxes shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.
    b. Floor boxes shall provide flush or recessed device outlets that will not obstruct the floor area. Refer to Drawings for size and types. This specification covers concrete

and wood frame floor applications with Wiremold 800, 860 and 880 and RFB Series boxes.

c. Cast-Iron Boxes: Box interior and exterior shall be painted. Boxes shall be available in 1,2, and 3 gang configurations. Boxes shall also be available in deep and shallow versions. Box shall provide 1-3/4 inches of pre-pour adjustment and 1/2 inch of post-pour adjustment.

d. Steel Boxes: Boxes shall be manufactured from stamped steel and formed. Boxes shall be available in 1,2, and 3 gang configurations. Boxes shall also be available in deep and shallow versions. All stamped steel versions shall provide 1-3/4 inches of pre-pour adjustment and 1/2 inch of post-pour adjustment.

e. Nonmetallic Multi-service Floor Boxes: Boxes shall be manufactured through the use of injection molded Geon M3900 PVC material. The box shall be rectangular in shape. Boxes shall allow for ganging of boxes together through a dovetail interlocking mechanism. Knockouts shall be provided on the side walls of each box to provide for pass-through capability between each gang. Boxes shall also have concrete depth markings on the exterior of the box to indicate box depth at the time of the pour. Boxes shall also provide graduated cubic inch markings on the interior of the box to indicate volume capacity at the appropriate box depth. Box shall accommodate concrete depths from 3-1/2 inches minimum to 6 inches maximum.
    1) Floor boxes shall provide (2) 1-1/4 inch conduit openings to feed cabling to the box. Boxes shall provide the means to reduce this opening to fit 1 inch, 3/4 inch and 1/2 inch conduit sizes. Box shall be equipped with a high impact mudcap to protect the box from damage and prevent concrete entry during the pour and debris entry after the pour. Box shall also provide ratchet teeth along interior box walls to attach cover. Box shall include internal spacer to prevent deformation of the box sidewalls when high temperature additives are used in the concrete pour.
    2) Adjusting rings shall be used to attach flanges and covers to the floor box body. Adjusting ring shall have ratchet teeth to align with the teeth on box wall to connect box body without the use of adhesive or mechanical fasteners. Adjusting ring shall provide for 10 degrees of adjustment after concrete pour to adjust to various concrete conditions and floor finishes. Provide brass inserts to mount finish flanges to box body. Adjusting ring shall also provide for grounding locations using brass inserts.
    3) Adjusting ring shall provide the ability to accept a modular connectivity system. Modular communication inserts shall snap directly into the adjusting ring openings. Adjusting ring shall provide a fiber storage loop to maintain proper fiber optic bend radius control and excess fiber storage. Each adjusting ring shall except up to six connectivity activation locations. Adjusting ring shall allow modular connectivity inserts to be mounted recessed and protected when not in use.

f. Covers and Flanges:
    1) Floor box options shall accept aluminum, brass and nonmetallic cover plates and flanges.
    2) Flanges shall be available in one-, two-, and three-gang applications. Each flange shall provide 1/2 inches of adjustment to accommodate various floor coverings and concrete depths.
    3) Flanges shall accommodate connectivity outlets and modular inserts.
    4) Modular inserts shall snap directly into each flange using a mounting bezel.

g. Multi-Compartment Boxes:
    1) Boxes shall be fully adjustable, providing a maximum of 1-7/8 (RFB4) 2” (RFB9/RFB11) inch pre-pour adjustment, and a maximum of 3/4 inch post-pour adjustment.

2) Boxes shall provide a series of device mounting plates that will accept both duplex power devices, as well as plates that will accommodate connectivity and AV outlets with modular inserts.
3) The box shall provide ¾", 1" and 1 ¼" conduit size openings with 2" KO for larger size boxes.
4) Cover shall be cast aluminum. Lid shall be offered with solid, flush surface for tile, wood or terrazzo and an insert option for carpet inlay.
5) Cover options shall support loads from 390LBS to 3000LBS
6) Use cast iron boxes for on-grade applications (RFB4-CI-1). Stamped steel allowed for above grade applications (RFB-4 and RFB-4DB).

10. Pull boxes: All site pull boxes shall be flush in-ground concrete, with engraved covers identifying service use (i.e. electrical, communications, etc.). Boxes shall be Nema 250, Type 6, outside flanged, with recessed cover for flush mounting, by Christy or equal, with required depth to provide box and conduit depths shown or required.
    a. Provide concrete covers for all boxes in planted or paved areas (up to available concrete cover size).
    b. Provide galvanized steel covers for all larger boxes (when concrete is not available), or in traffic areas. No cast iron covers.
    c. Provide bolted covers and slab bottoms (with grouted perimeter) or vault type boxes for all electrical distribution and signal system pull boxes used for site distribution, to prevent rodent entry. No collar type boxes with dirt or gravel bottoms
    d. Provide drain hole at bottom of all vault type boxes, with loose aggregate base below, for proper drainage.
    e. All covers to be completely flush with finished adjacent surfaces.
    f. Provide galvanized steel H20 rated covers and installation of box rated for H20 in all traffic areas.
    g. Provide pullboxes per utility company specifications for all electrical primary and secondary services and for telecommunications service runs. Verify exact size and type prior to order with each utility company.

C. Wire and Cable (line voltage and signal systems):
    1. 600-volt class where used for or run with line voltage power wiring, insulation color coded, minimum No. 12 AWG for power branch circuits, No. 14 for power control circuits, and wiring size and type as directed by signal system manufacturer for each signal system.
    2. All conductors shall be copper.
    3. Size and insulation type:
        a. Use 75 degree C insulation ratings on this project, regardless of insulation allowable ratings, unless specifically indicated otherwise on the drawings.
        b. Standard locations: #12 to #1 AWG: THWN/THHN dual rated for all wet and dry locations; #1/0 through #4/0 AWG: XHHW (55 Mils) for all wet and dry locations; 250MCM and larger: XHHW (65 Mils). All wire sizes used shall be based on a 75 degree insulation rating, unless specifically used with 90 degree rated breakers and devices.
        b. All wiring (power and signal) installed underground between buildings, or in wet or damp locations, shall be outside listed and rated for wet locations.
        c. High temperature and non-standard locations: Provide wire type and insulation category suitable for area of use as defined in NEC Article 310.
        d. Photovoltaic applications: provide 90 degree C insulation ratings.
    4. Conductors No. 8 and larger and as otherwise noted on drawings shall be stranded. Power conductors No. 12 and No. 10 shall be solid or stranded. Power conductors No. 14 or smaller shall be solid.
    5. Provide signal system wiring for each system to meet the system manufacturers requirements and recommendations for each device or equipment type. Signal wiring

systems shall be provided with shielding and/or insulation type and cable quantities as directed by the manufacturer, and meet all NEC requirements for locations used.

6. Install all wiring branch circuits and feeders (low voltage and line voltage) in conduit unless noted otherwise on the drawings. Contractor shall mandrel all feeders and pass a "sock" (or utilize other suitable means) through each raceway prior to pull to remove all water and construction debris. All raceways shall be completely clear of any obstructions or debris and all cut ends shall be reamed, prior to pull. Utilize pulling compound on all runs to insure minimum friction and pulling tension.
7. Megger test all feeders prior to energizing. See section 26 08 00 for additional information.
8. Approximately balance branch circuits about the neutral conductors in panels.
9. Connections to devices from "thru-feed" branch circuit conductors to be made with pigtails, with no interruption of the branch circuit conductors.
10. Neutral conductor identified by white outer braid, with different tracers of "EZ" numbering tags used where more than one neutral conductor is contained in a single raceway.
11. Neatly arrange and "marlin" wires in panels and distribution panelboards with "T and B Ty-rap" or approved equal plastic type strapping.
12. All wire and cable shall bear the Underwriters' Label, brought to the job in unbroken packages; wire color-coded as follows:

Voltage	Phasing	A	B	C	N
120/208	3PH4W	Black	Red	Blue	White
2083PH	3W	Black	Red	Blue	--
277/480	3PH4W	Brown	Orange	Yellow	White
4803PH	3W	Brown	Orange	Yellow	--

13. The equipment grounding conductor shall be insulated copper; where it is insulated, the insulation shall be colored green.
14. Label each wire of each electrical system in each pull box, junction box, outlet box, terminal cabinet, and panelboard in which it appears with "EZ" numbering tags indicating the connected circuit numbers.
15. Properly identify the “high leg” of 4-wire delta connected systems (in each accessible location) as required by NEC 110.15 and 230-56.
16. Provide permanently affixed adhesive labels with machine printed lettering (min. 1/8" high) at junction boxes serving fixtures that are supplied by (2) electrical sources (i.e. normal and emergency lighting). Label to read "CAUTION - This light fixture is powered by (2) separate sources. The normal power source breaker and the emergency power source breaker must be turned off before servicing this light fixture."
17. Install feeder cables in one continuous section unless splices are approved by Architect. Exercise care in pulling to avoid damage or disarrangement of conductors, using approved grips. No cable shall be bent to smaller radius than the spool on which it was delivered from the manufacturer. Color code feeder cables at terminals. Provide identifying linen tags in each pullbox.

D. Switches: Model numbers are Hubbell, color to be selected by architect, unless otherwise noted. All switches to utilize screw terminals for wire connections - no plug-in terminations:
   1. Single Pole - No. HBL1221
   2. Two Pole - No. HBL1222
   3. Three Way - No. HBL1223
   4. Momentary contact - No. HBL1557
   5. Momentary contact Keyed - No. HBL1556L
   6. Keyed, - No. HBL1221L
   7. Pilot Light (on with load on) - Hubbell No. 1221-PLC
   8. Motor Rated Double Pole (30A) - Hubbell No. 7832
   9. Motor Rated Three Pole (30A) - Hubbell No. 7810.

10. Low voltage Data line switches - Refer to lighting control system (for compatibility)

E. Receptacles: Mounting straps and contacts shall be one piece design, constructed of minimum .050" solid brass. Base shall be high strength, heat resistant, glass reinforced nylon. Device shall accept up to #10 wire, side or back wired with screw terminals - no plug-in terminations. Hubbell, Leviton, Pass & Seymore, or equal. Color to be selected by architect, unless otherwise noted. Numbers listed below are Hubbell:
   1. 15A 3PG 125 volt duplex - No. HBL5262
   2. 20A 3PG 125 volt duplex - No. HBL5362
   3. 20A 3PG 125 volt ground fault interrupter receptacle; GFI receptacles shall conform to the 2006 UL requirements to a) interrupt power to the unit in the event of internal failure, or b) provide an audible or visual indication of internal failure of the GFI; No. GF20 or equal. Through wiring to down stream GFI designated receptacles is not acceptable.
   4. 15A 3PG 125 volt half controlled duplex receptacle - No. BR15C1(color), with permanent "controlled" marking, factory applied.
   5. 20A 3PG 125 volt half controlled duplex receptacle - No. BR20C1(color), with permanent "controlled" marking, factory applied.
   6. 15A 3PG 125 volt full controlled duplex receptacle - No. BR15C2(color), with permanent "controlled" marking, factory applied.
   7. 20A 3PG 125 volt full controlled duplex receptacle - No. BR20C2(color), with permanent "controlled" marking, factory applied.
   8. GFI Module (blank face), no indicator light, 20A – No. GFBF20 or equal.
   9. All receptacles located in exterior or wet locations shall be corrosion resistant with UV stabilized body.

F. Plates: Leviton, or equal, except as noted:
   1. The color of all faceplates shall match the color of the devices installed under/in the faceplate, except as specifically noted otherwise.
   2. For flush outlet boxes, for switches, and receptacles: nylon, color to be selected by architect, unless otherwise noted.
   3. Plates for surface-mounted outlets: galvanized steel unless otherwise noted.
   4. Weatherproof duplex receptacle plates for exterior locations with ground fault interrupter receptacles in type FS or FD boxes – Hubbell #WPFS26 or compatible equal. Verify cover compatibility with box type and device installed.
   5. Weatherproof "in-use" cover, vertical or horizontal mount, for exterior with GFCI receptacles. Die-cast metal alloy, TayMac MX series or equal with openings to match installed devices.
   6. Locking plates for duplex receptacles where noted; Pass & Seymour #WP26-L (non-weather proof).
   7. Locking plates for duplex exterior GFCI receptacles (or in wet or damp locations); Heavy duty cast aluminum flush cover with locking latch and key, Pass & Seymour #4600 with appropriate mounting plate for type of device installed. Coordinate backbox requirements and finished wall trim-out with wall installer prior to rough-in to insure an adequate and neat trim appearance upon completion.
   8. Plates for flush tele/data boxes: white nylon or as otherwise directed - provide and install at each tele/data outlet plate to match duplex power outlet plate, for jack installation under Section 27 00 00. Where the power and tele/data outlet boxes are shared the plate shall be continuous in multi-gang locations. See drawings.

G. Equipment Disconnects: All disconnects shall be located to allow proper code required clearance in each area. Locations shown on drawings are diagrammatic only. The contractor shall coordinate exact locations in the field (with other trades) prior to rough-in to insure proper clearances.
   1. Motor Disconnect Switches and Safety Switches: General Electric Company Heavy Duty Type "THD", cover interlocked with operating handle so that cover cannot be opened with

switch in closed position and switch cannot be closed with cover in open position. 240V or 480V rating, single or multi-pole as required or as noted on drawings, in Nema 1 enclosure indoors or Nema 3R enclosure outdoors unless otherwise noted. Provide dual element motor circuit fuses sized as recommended by equipment manufacturer (for final equipment actually installed).

2. Code required disconnects: Provide a local disconnect in addition to the branch circuit protection device for all equipment as required by code (whether shown or not). Disconnects shall consist of a motor rated switch (or disconnect) for all motor loads less than 3/4HP or other suitable disconnect sized to match branch circuit conductors and load current of equipment, with number of poles as required.

H. Lugs and Connectors: Thomas and Betts "lock-tite", for No. 4 and larger wire; 3M "Scotchlock" fixed spring screw-on type wire connectors with insulator for No. 6 and smaller wire.
   1. All splices shall be made up with screw-on type connectors - no plug-in or push-in style connectors acceptable. Wires shall be solidly twisted together with electricians pliers before screw-on connector is installed to ensure a proper connection in the event of wire nut failure. No exceptions.
   2. Connectors listed or labeled for “no wire twisting required” are not an acceptable substitute for actual wire twisting.
   3. Utilize porcelain type connectors in all high temperature environments (above 105 degrees Celsius).

I. Splice Insulation: "Scotch" electrical tape with vinyl plastic backing or rubber tape with protective friction tape for interior work.
   1. Splices in electrical cables of 600 volt insulation class in underground system duct shall be made only in accessible locations such as pullboxes, light pole handholes, etc., using a compression connector on the conductor and by insulating and waterproofing (for exterior and underground locations) by one of the following methods:
      a. Cast type splice insulation shall be provided by means of a molded casting process employing a thermosetting epoxy resin insulating material which shall be applied by a gravity poured method or by a pressure injected method. The component materials of the resin insulation shall be in a packaged form ready for convenient mixing after removing from the package. Do not allow the cables to be removed until after the splicing material has completely set.
      b. Gravity poured method shall employ materials and equipment contained in an approved commercial splicing kit which includes a mold suitable for the cables to be applied. When the mold is in place around the joined conductors, the resin mix shall be prepared and poured into the mold. Do not allow cables to be moved until after the splicing materials have completely set.

J. Identification: Refer to Section 260500.

K. Firestopping: as manufactured by 3M Fire Protection Products or equal.
   1. Fire-rated and smoke barrier construction: Maintain barrier and structural floor fire and smoke resistance ratings including resistance to cold smoke at all penetrations, connections with other surfaces or types of construction, at separations required to permit building movement and sound vibration absorption, an at other construction gaps.
   2. Systems or devices listed in the UL Fire Resistance Directory under categories XHCR and XHEZ may be used, providing that it conforms to the construction type, penetration type, annular space requirements and fire rating involved in each separate instance, and that the system be symmetrical for wall penetrations. Systems or devices must be asbestos free.

PART 3 - EXECUTION

3.1 REFER TO BASIC ELECTRICAL REQUIREMENTS - SECTION 260500 FOR WORK UNDER THIS SECTION.

3.2 TESTS

A. Testing and Inspection: See Section 260800 - Testing.

END OF SECTION

SECTION 263200

EMERGENCY ELECTRIC GENERATOR

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide a complete Emergency Generator plus accessories in a single common housing, as noted herein and as indicated on the Drawings.

B. Provide CBC 2019 compliant seismic installation. See Section 260500 for all certification and submittal requirements.

C. Manufacturer shall be responsible for providing a complete assembly of all components in one overall housing with base tank, which is certified to comply as an integrated assembly with CBC 2019 requirements.

D. Manufacturer shall provide technical assistance to Owner in securing all required local Air Quality Management District permits for installation of the Emergency Generator, including review and inclusion of existing engine generators where applicable on the same site in site analysis.

E. The Contractor shall include a Manufacturer-provided three-year engine-generator maintenance agreement as described herein as part of the bid. The maintenance agreement shall include an annual 2-hour full load test using a portable load bank.

1.2 SUBMITTALS

A. Refer to Section 260500 for procedure.

B. Tests and Reports (Test Requirements are detailed in Paragraph 1.4).
   1. Provide certified test reports of the following:
      a. Factory tests.
      b. Field Tests: Test reports shall include dates performed, method of testing, test results, test interpretation and recommended action.

C. Shop Drawings and Product Data
   1. The following list includes the required Shop Drawing information that shall be submitted for the generator:
      a. Physical dimensions and weights.
      b. CBC Special Certificate of Compliance with importance factor of 1.5 for all components and overall assembly.
      c. Brake horsepower of engine.
      d. Fuel consumption.
      e. Cooling requirements.
      f. Noise db level. Provide details of acoustical housing and factory testing to prove acoustical housing performance (71dbA at 7 meters).
      g. Electrical characteristics of generator, voltage regulator, and battery charger.
      h. Load graphs.
      i. Control panel.
      j. Elevation.
      k. Wiring and control diagrams.
      l. Engine and generator details, including governor and base fuel tank.
      m. Location of available parts and service.

n. Confirmation that engine meets the latest required EPA Tier Exhaust Emission Compliance Statement, complies with latest CARB requirements for emergency standby equipment, and complies with the local Air Quality Management District requirements.
o. Details of base tank fill connection, including overfill basin.
p. Details of primary tank venting, primary and secondary tank emergency relief venting, high fuel alarm panel and sensing, and tank labeling.
q. Passive diesel particulate filter.

D. Maintenance and operating instruction manuals, six bound copies, including approved shop Drawings, parts list, list of recommended spare parts, sources of purchase and similar information.

1.3 GUARANTEE

A. Provide a written guarantee against all defects in materials and application, which prevent proper functioning for one (1) year from date of acceptance of the project.

1.4 TESTS

A. Certified copies of factory test giving guaranteed performance characteristics to meet the Specifications should be furnished by the Manufacturer. The unit shall be tested at the Manufacturer's plant for performance of all functions including a 2-hour full load test, using 0.8pf reactive to 1.0pf resistive load banks and until all temperatures have been stabilized for at least 30 minutes.

B. The Manufacturer shall have field tests made of the generator and wiring systems in place by a qualified factory technician. The complete engine generator set with all of its appurtenances shall be tested after installation for all functions, including a 2-hour full load test with full-rated resistive (1.0pf) load bank. The Manufacturer shall supply all equipment necessary for the tests.

C. Testing of fuel system – see Part 3 of this Section.

1.5 FUNCTION

A. The emergency generator shall function to start automatically immediately upon power failure of the normal power supply, assume full load within ten (10) seconds and automatically switch into the emergency power system. The unit shall be automatically removed from the line upon resumption of normal power and stopped five (5) minutes later.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
1. Provide and install a complete emergency power system, including power plant powered by diesel engine driven generator and operated by means of a signal from an automatic transfer switch. The system shall be complete, tested and meet all the functional requirements of a fully automatic emergency power source serving full load power stabilized at rated voltage and frequency within three seconds after normal power source failure.
2. The diesel engine generating set shall be fully automatic and shall be complete with starting and control equipment, base fuel-tank, skid-mounted batteries, charger, acoustical enclosure, and other equipment necessary to provide a complete, fully automatic system.

3. Arrange for the services of a factory erection engineer for checking installation, making specified and all other necessary tests, making initial start, instructing operating personnel in operating unit through all of its functions to ensure that the unit is performing in accordance with the intentions of the Specifications.
4. Generator set shall be provided with a vertical scoop on discharge.
5. Manufacturers: Cummins-Onan, Kohler, or Caterpillar. The Kohler unit shall utilize a Detroit Diesel engine – no other engine manufacturer will be accepted for a Kohler unit.
6. Generator set shall be provided with a passive diesel particulate filter (DPF) mounted above engine-generator in a common housing with the generator set.

B. Power Plant:
1. Rating shall be based on continuous standby power rating of the generator and with capabilities to carry 100% full load without damage to the engine, generator or components, and with capabilities for starting the largest motor scheduled for the standby power system while carrying full connected load at an altitude of 350 feet above sea level. Full load power ratings shall be as indicated on the drawing, continuous standby at 0.8 PF at 277/480V 3PH 4W or 120/208V 3PH 4W where indicated on the drawings.
   a. Voltage regulation shall be +/-0.5% for any constant load between no load and rated load.
   b. Frequency regulation shall be isochronous from steady state no load to steady state rated load.
   c. The diesel engine generator set shall be capable of single step load pick up of 100% nameplate KW and power factor, less applicable derating factors, with the engine-generator set at rated operating temperature.
   d. Under motor starting conditions the generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified KVA load at near zero power factor applied to the generator set.
   e. Maximum transient voltage dip shall not exceed 35 percent below rated on application of the single largest surge load step.
2. Provide unit and all accessories in a common weatherproof acoustical enclosure, with a common base for unit capable of skidding into place. Provide sound absorbing insulation on interior of weatherproof enclosure to produce overall sound rating noted above. All accessories, including muffler shall be concealed within common generator enclosure. If a diesel particulate filter is specified, it shall be concealed within the enclosure.
2. Provide minimum 18" flexible section in all electrical, fuel and exhaust lines at connection to power plant.
3. Provide flexible steel disc coupling to engine-generator.
4. Provide lifting brackets.
5. Provide a CBC 2016 compliant and certified vibration isolation system. The vibration isolation system shall be designed to withstand the seismic forces from ground motions and installation shall comply with critical equipment (importance factor = 1.5) requirements. CBC conforming vibration isolators shall be provided and installed at the bolt-down locations between the skid and the base fuel tank.

C. Engine:
1. The engine shall be 4-cycle design, water-cooled; series turbo charged with after cool, having no inherent unbalanced reciprocating forces. Operating speed shall be 1800 RPM.
2. Starting by battery-driven starter. Include cranking sequencer, which shall give three (3) start attempts before locking out over-cranking protection.
3. Governor shall be isochronous electronic as required to maintain generated frequency at 60 Hz. at 75% full load within a steady state band-width of (+/-) 0.25%. Frequency shall not vary over 3% from no load to full load. Governors using engine crankcase lube oil will not be acceptable. Governor shall be type EFC, Electronic Isochronous.

4. Provide fuel and lubrication systems for diesel engine, complete with replacement element type air cleaner; primary and secondary fuel filter and oil filter; full pressure lubrication system with positive displacement lube oil pump and spring-loaded bypass valve; lube oil cooler; engine driven fuel transfer pump; extended base-mounted fuel tank, sight gauge, automatic float switch to maintain fuel level, and high-fuel and low-fuel alarm dry contacts for local and remote indication. Provide base fuel tank rupture basin contacts (2 sets) for local and remote alarm. Point of fuel fill at the base tank shall have provisions for spill containment. Provide shop drawings indicating spill containment system.
5. Provide a cooling system with sufficient capacity for cooling engine when generator is delivering 100% full load for four hours at ambient of 40 degrees C at an altitude of 350 feet. Include water-circulating pump and thermostatic valve to maintain recommended engine temperature; radiator with drain and air vent and fan with protective guard; jacket water corrosion resistant heating elements (wattage as specified by engine manufacturer, rated at 208V 1PH or 3PH). Radiator shall be filled with antifreeze solution of strength as recommended by Manufacturer. Exhaust air shall be discharged vertically, using a scoop design.
6. All areas within 24 inches of the muffler shall be covered with 6 lb. density mineral wool. All piping shall be schedule 40 black pipe.
    a. The exhaust system, piping, and insulation shall be factory supplied and installed. Extend black standard weight iron pipe from the engine with 18" flexible connection between engine and muffler. The muffler shall be installed within the same overall enclosure as the engine-generator.
7. Provide a unit-mounted battery for engine start, 24-volt DC with a capacity of not less than 160-ampere hours at 20-hour rate. The battery shall also be sized for six starts of 30-second cranking duration each, with ambient 15 degree F, mounted on earthquake-proof tray on pad with all necessary battery cables, hydrometer and enclosure-mounted voltage-regulated battery charger in Nema 3R enclosure with float, taper, and equalize charge settings and with DC voltmeter, DC ammeter and circuit for low voltage alarm. Battery shall be lead-acid type.
8. Auxiliary switches for over-speed trip and automatic over-speed shut down at a speed 10% greater than the normal specified operating RPM. The engine shall shut down on over-speed, low oil pressure, high oil temperature and high water temperature by means of auxiliary switches, actuating signal lights and alarms.
9. Temporary batteries may be used for testing, but new, unused batteries shall be furnished after final testing is complete and before acceptance. New batteries shall be used for one generator start to demonstrate adequacy of final battery installation.
10. Engine exhaust emissions shall meet the latest adopted EPA Tier Exhaust Emission Compliance Statement, the latest CARB requirements for emergency standby applications, and the local Air Quality Management District standards.
11. Provide a DPF - concealed within enclosure.

D. Diesel Particulate Filter: The DPF shall be a passive continuously regenerating type as manufactured by Johnson Matthey, or equal.
    1. DPF shall meet latest EPA and CARB requirements and be on the CARB-approved and verified list for latest emissions standards.
    2. It shall meet all applicable CARB requirements for after-treatment of engine-generator emissions.
    3. The DPF shall solely use the heat of the engine exhaust and not require any supplemental heat source. The DPF shall regenerate and remain continuously operational even if the KW load on the engine-generator is no more than 25% of nominal.
    4. The DPF shall be supplied with a monitoring device which shall log exhaust temperature and backpressure when the engine is running. Back pressure and pressure on the engine shall be continuously monitored as they increase due to build up of the ash layer in the filter. The monitoring device shall derive 24 volt DC power from engine-generator control panel – all connected complete by Manufacturer. It shall

have an RS232 interface and be provided with software to download the data onto a portable computer. It shall have alarm points which can be set to indicate the increase in backpressure based upon the Manufacturers' specifications.

5. The DPF shall be housed within a carbon steel, fully insulated, corrosion resistant shell with removable cover panels for full access to the diesel particulate filters mounted inside. The DPF stainless steel shell shall in turn be mounted within the common overall generator housing, with housing access panels aligning with the shell access panels to the filters.
6. The DPF shall have critical-grade sound attenuation.

E. Generator:
   1. Rated for continuous standby service, complying with NEMA standards.
   2. Brushless, balanced 4-pole revolving field type with rotating rectifier exciter mounted on end of shaft, single ball bearing support to starter housing, rotor connected by semi-flexible steel disc coupling to engine flywheel to assure permanent alignment free of injurious tensional vibrations at speeds up to 125% of synchronous. Rated for 105 degrees Centigrade rise.
   3. Generator insulation shall be in accordance with latest NEMA standards using minimum Class H materials. All insulation system components shall meet NEMA MG1 temperature rise limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees centigrade.
   4. A permanent magnet generator (PMG) shall provide excitation power for immunity to voltage distortion caused by non-linear loads. The PMG shall sustain excitation power for optimum motor starting and to sustain short circuit current at approximately 300% of rated current for not more than 10 seconds.
   5. Voltage regulator of static solid state design to give (+/-) 2% regulation from no--oad to full load; instantaneous voltage dip less than 20% of rated when full load at rated power factor suddenly applied; and recovery to stable operation of voltage within 1% of rated within four seconds. The voltage regulator shall be of the asynchronous pulse width modulated type and shall be insensitive to severe load-induced waveshape distortion from SCR or thyristor circuits such as those used in UPS and motor speed control equipment. Manual adjustment of (+/-) 5% of normal to be included by a lockable device or screwdriver slot in rheostat shaft. All voltage sensing shall be 3-phase.
      a. The automatic voltage regulator shall be temperature compensated, solid-state design. The voltage regulator shall control build up of AC generator voltage to provide a linear rise and limit overshoot. The regulator shall include a torque-matching characteristic, which shall use differential rate of frequency change compensation to use the maximum available engine torque and provide optimal transient load response. Regulators, which use a straight line fixed volts per hertz characteristic, are not acceptable.
   6. Shielding of generator, exciter and regulator to prevent radio frequency interference.
   7. The generator, exciter, and voltage regulator shall be designed and manufactured by the engine-generator set manufacturer so that the characteristics shall be matched to the torque wave of the engine to provide the fastest possible system recovery from transient load changes and to prevent engine stall during transient overload conditions.

F. Control Equipment:
   1. Panel mounted with vibration isolators to plant frame. Top of panel shall not exceed 6'-6" above slab with generator mounted to a 30" high base tank on top of a 3" high pad.
   2. The generator set shall be provided with a microprocessor-based control system, which shall be designed, to provide automatic starting, monitoring and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set and remote monitoring and control as described in this Specification. The control panel shall be mounted on the generator set.
   3. The control panel shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

4. The control panel shall be UL508 labeled, CSA282-M1989 certified and meet IEC8528 part 4. All switches, lamps and meters shall be oil-tight and dust-tight and the enclosure door shall be gasket. There shall be no exposed points in the control panel (with the door open) that operate in excess of 50 volts. The controls shall met or exceed the requirements of Mil-Std 461C part 9 and IEC Std 801.2, 801.3 and 801.5 for susceptibility, conducted and radiated electromagnetic emissions. The entire control shall be tested and meet the requirements of IEEE587 for voltage surge resistance.
5. The generator set mounted control panel shall include the following features and functions:
    a. Three position control switch labeled RUN/OFF/AUTO: In the RUN position the generator set shall automatically start and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
    b. Red “mushroom-head” push-button EMERGENCY STOP switch: Depressing the emergency stop switch shall cause the generator set to immediately shut down and be locked out from automatic restarting.
    c. Push-button RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
    d. Push-button PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed or after the switch is depressed a second time.
    e. Generator Set Metering: The generator set shall be provided with a metering set with the following features and functions:
        (1) 2.5-inch, 90-degree scale analog voltmeter, ammeter, frequency meter and kilowatt (KW) meter. These meters shall be provided with a phase select switch and an indicating lamp for upper and lower scale on the meters. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.
        (2) Digital metering set, 0.5% accuracy, RMS type to indicate generator voltage, frequency, output current, output KW, KW-hours and power factor. Generator output voltage shall be available in line-to-line neutral voltages and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
    f. Generator Set Alarm and Status Indication: The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status and existing alarm and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel.
        (1) Low oil pressure (alarm)
        (2) Low oil pressure (shutdown)
        (3) Oil pressure sender failure (alarm)
        (4) Low engine temperature (alarm)
        (5) High engine temperature (alarm)
        (6) High engine temperature (shutdown)
        (7) Engine temperature sender failure (alarm)
        (8) Low coolant level (alarm or shutdown--selectable)
        (9) Fail to crank (shutdown)
        (10) Over-crank (shutdown)
        (11) Over-speed (shutdown)
        (12) Low DC voltage (alarm)
        (13) High DC voltage (alarm)
        (14) Weak battery (alarm)

(15) Low fuel-base tank (alarm)
(16) High AC voltage (shutdown)
(17) Low AC voltage (shutdown)
(18) Under frequency (shutdown)
(19) Over current (warning)
(20) Over current (shutdown)
(21) Short circuit (shutdown)
(22) Ground fault (alarm)
(23) Under frequency (alarm)

In addition, provisions hall be made for indication of two customer-specified alarm or shutdown conditions. The non-automatic indicating lamp shall be red and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

g. Engine Status Information: The following information shall be available from a digital status panel on the generator set control:
   (1) Engine oil pressure (psi or kPA)
   (2) Engine coolant temperature (degrees F or C; both left and right bank temperature shall be indicated on V-block engines)
   (3) Engine oil temperature (degrees F or C)
   (4) Engine speed (rpm)
   (5) Number of hours of operation (hours)
   (6) Number of start attempts
   (7) Battery voltage (DC volts)

h. The Generator Control Panel shall monitor the status of each Automatic Transfer Switch. The monitoring for each Automatic Transfer Switch shall be:
   (1) ATS Normal Position
   (2) ATS Emergency Position

i. The ATS status for each switch shall also be displayed on the Generator Remote Annunciator.

6. Control Functions: The control system provided shall also include a cycle cranking system, which allows for user selected crank time, rest time and number of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each with 15-second rest periods between cranking periods.
7. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode the alternator excitation system shall be disabled.
8. The control system shall include an engine governor control which functions to provide steady state frequency regulation as noted elsewhere in this Specification. The governor control shall include adjustments for gain; damping and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.
9. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
10. The control system shall include sender failure monitoring logic, which is capable of discriminating between failed senders or wiring components and an actual failure conditions.

G. Remote Indicator Panel: The remote annunciator panel shall be surface or flush-mountable with micarta label reading "Engine Operator Conditions," and with the following devices:
   1. Green pilot light with engraving to indicate "ENGINE RUNNING."
   2. One audible alarm with silencing switch to indicate engine start failure for any of the following reasons:
      a. High water temperature.
      b. Low oil pressure.
      c. Over-speed.
      d. Over-crank.
      e. Low battery voltage.

f. Low-level fuel alarm.

3. Remote indicator panel shall include an amber light indication for each of the following:
   a. Control switch not in auto position.
   b. Low water temperature.
   c. ATS in normal position (for each ATS).
   d. ATS in emergency position (for each ATS).
4. Each of the functions listed previously in Paragraphs 2.(a) through (f) shall be indicated by a separate red warning light and each warning light shall be so engraved.

H. Fuel System: The fuel system shall conform to NFPA 30 and 37. The fuel system shall be complete and shall consist of a dual filtering system, and engine fuel pump. The engine shall start, operate, and stop on DF-2 fuel.

1. Fuel Filtering System: The fuel filtering system shall consist of a strainer, located between the storage tank and the fuel transfer pump, and a duplex fuel filter, located between the engine fuel pump and the engine. The filtering system shall be capable of removing from the fuel system flakes, dirt, metallic chips, carbon, water, or other foreign matter, which would be harmful to the engine. The filtering system shall be easily accessible for quick-and-easy replacement of the filter element and cleaning of the strainer. Components of the filtering system shall be the standard products of the engine Manufacturer.
2. Engine Fuel Pump: The engine fuel pump shall be a positive-displacement, engine-driven pump capable of supplying an adequate quantity of fuel to the engine under all operational conditions. Solenoid shut-off valve in fuel line discharge side of pump shall be interlocked with the emergency engine shutdown circuitry.
3. Fuel Tank: The fuel tank shall be skid mounted under the engine, and shall be capable of providing an immediate fuel supply to the engine fuel pump. The tank shall be no more than 30” high. The tank shall be provided with a flexible tubing suction line to the engine, an excess fuel return line from the engine to the tank, a fuel gauge, a vent, a drainpipe, and high and low-level float switches for activating the low-level alarms. Usable fuel tank capacity shall not exceed 660 gallons – see drawings for exact capacity of fuel tank. The tank shall be a full double wall, U.L. listed design and shall be factory tested in accordance with the requirements of U.L. 142. The outer containment cavity shall be equipped with an emergency leak-detection float switch for the leak detection and alarm system. The tank shall as a minimum include the following:
4. Primary tank venting shall be provided and shall be a minimum of 1.25" nominal inside diameter. The primary vent shall be extended thru the roof of the generator enclosure to a height not less than 12 feet above grade. The normal vent shall have a screened mushroom style cap.
5. Emergency relief venting shall be provided for both the primary and secondary tanks. Rain protected, open style rupture basins are not acceptable. These vents shall be extended thru the roof of the generator enclosure to a height of not less than 12 feet above grade. The extended emergency vents shall be capped with U.L. listed pressure relief type caps designed to open at 2.5 PSI. Materials used for vent pipes, supply and return piping, valves and fittings shall conform to Article 79, Division VII.
6. A 5 gallon capacity overfill basin shall be provided around the fill pipe and shall include a means of draining spills back into the main tank. The fill pipe shall be extended down into the fuel tank and terminate within 6" of the bottom of the tank.
7. The high fuel sensor shall be wired to an audible and visual local alarm that shall be activated at 90% of the tank capacity. The alarm panel shall be mounted at the fill location and shall include a reset/silence for the alarm and light that will automatically reset the controller for the next fill. An "off switch" is not acceptable.
8. The tank shall include labels to indicate "Diesel Fuel". The lettering shall be 3" high, half-inch stroke, red letters on a white background outlined in red.
9. All of the above items shall be submitted for approval. Do not release the fuel tank for manufacture until it has been approved.

I. Output Circuit Breakers:
   1. Provide engine-generator mounted circuit breakers for each automatic transfer switch, and where indicated on the drawings one for a portable load bank, with ratings as noted on the Drawings. Breaker handles shall not exceed 6'-6" above grade when engine-generator is mounted to a 30" high base fuel tank on top of a 3 inch high structural isolation pad.

J. Weather Protective Sound Attenuated Enclosure:
   1. The generator set and accessories, including muffler, shall be completely housed in a weather protective and sound attenuated enclosure. The enclosure shall have a cambered roof to prevent rain accumulation, shall include stainless steel hardware to prohibit rust, and shall include stainless steel retainers to hold doors securely in place. The enclosure sound level shall be as specified herein. The generator set, enclosure, and sub-base fuel tank shall be U.L 2200 listed as a package.
   2. Material used for the enclosure shall be 14-gage steel for panels and 12-gage steel for posts. Three hinged lockable access doors shall be provided on each side, with hold-open retainers as indicated in Paragraph 1 above. Non-hygroscopic sound insulating materials shall be provided on the interior walls. Rodent barriers shall be provided on inlet and outlet sides. Louvers shall be fixed. The enclosure shall attach to the sub-bases fuel tank. Oil and coolant drains shall be run to the exterior of the enclosure. Interior valves on the oil and coolant lines shall be provided for ease of service.
   3. The enclosure shall completely house the muffler on the generator set.
   4. Provide sheet metal scoop on radiator output, to direct the radiator exhaust air directly up and vertically out of the generator enclosure. Provide screen on output of scoop to prevent dirt, leaves, and bird incursions. Provide drain on floor of scoop to drain off any water. Provide access door in scoop for cleaning of any accumulated debris. Scoop shall be factory-mounted as part of the engine-generator package. Provide detailed shop drawings of scoop with engine-generator submittals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The engine-generator set shall be mounted on a rigid steel chassis suitable for installation on seismic isolators.

B. The Contractor shall assist the Owner in preparing and submitting a permit-to-construct application to the local Air Quality Management District for installation of the engine-generator. The Contractor shall pay for permit and permit approval fees, and the Owner shall pay for annual operational fees. Granting of such permit will require a site-specific screening application followed by an analysis by the local Air Quality Management District.

C. Load tests shall be run as required in Paragraph 1.4 of this Section to the generator rated load after generator installation is complete. The Manufacturer shall provide auxiliary load banks for full-load testing of the generator. Manufacturer shall schedule the tests with the Owner so that final tests may be witnessed. Verify correct reading and operation of all meters, indicators and controls.

D. Readings required during both preliminary and final tests requested in Paragraph 1.04 shall be taken and shall include the following:
   1. Frequency.
   2. Voltage.
   3. Current.
   4. Wattage.
   5. Ambient temperature.
   6. Water temperature.

7. Oil pressure and temperature.

E. Protection: Provide protection facilities and procedures to prevent damage and deterioration.

F. Verify utility phase rotation prior to connection of the Generator to the distribution system. Modify the Generator output phase rotation to match the Utility Company.

G. The Manufacturer shall perform the following fuel tank tests at the site after the installation is complete, but before the fuel is delivered. Tests shall be conducted in the presence of the Owner and shall include as a minimum the following:
   1. Primary tank shall be pneumatically tested at 5 psig for 30 minutes; during which time the connections to the primary tank shall be soap tested.
   2. Secondary tank shall be pneumatically tested at 3 psig for 30 minutes; during which time the connections to the secondary tank shall be soap tested.
   3. Primary piping shall be pneumatically tested at 150 percent of the maximum operating pressure for 30 minutes; during which time all fittings shall be soap tested.
   4. Secondary piping, if provided, shall be pneumatically tested at 5 psig for 30 minutes, with soap testing.
   5. Other secondary containment shall be liquid tight as demonstrated by a 24-hour standing water test.
   6. Correct operation of the leak detection system shall be demonstrated.

H. The DPF manufacturer’s authorized factory representative shall verify correct installation of the DPF and filter at the site prior to engine-generator start-up and shall perform all testing and commissioning of the DPF in conjunction with the engine-generator testing after the installation is complete. Tests shall be conducted in the presence of the Owner.

3.2 INSTRUCTION AND MAINTENANCE

A. Instruct the Owner's personnel in the proper use, operation and maintenance of the set. Review emergency provisions, including emergency access and procedures to be followed at time of failure in operation and other building emergencies. Train Owner's personnel in the procedures to be followed, checking for the source of an operational failure or malfunction.

B. Instruct the Owner's personnel in the proper use, operation and maintenance of the DPF, including maintenance and replacement of the filters and periodic use of a portable load bank to maintain DPF in optimum condition.

C. Maintenance Period: Starting at the date of acceptance of the Work, provide complete systematic inspection and maintenance for the first three years. Furnish trained experts and equipment to check, adjust, lubricate and otherwise maintain the generator set in operation without defects or deterioration. Replace or repair materials and parts, which become defective or deteriorated for any reason.

D. Furnish a factory-trained Engineer for a minimum of one working day prior to final acceptance of the generator installation, or as needed to satisfy Owner that the system is functioning properly. Testing and training for the new engine-generator installation will take place at non-standard times. Training and testing will take place on weekends, and could be scheduled on holidays and in the middle of the night, at the discretion of the Owner. Provisions shall be made in the bidding for this contract for such scheduling requirements.

E. Provide 3 year Manufacturer maintenance Contract, for the new engine-generator installation. This shall include two site visits per year and annual load-bank testing as specified in Paragraph 1.1 of this Section.

END OF SECTION

SECTION 263601
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide quantity of automatic transfer switches as indicated on the drawings and as specified herein.

1.2 SUBMITTALS

A. Refer to Section 260500 and Division 1 for procedure.

B. Shop Drawings and Product Data, including complete wiring diagrams, including system interconnections.

C. Test and Test Report for each Automatic Transfer Switch:
   1. Visual and Mechanical Inspection:
      a. Inspect for physical damage.
      b. Compare equipment nameplate information and connections with single line diagram and report any discrepancies.
      c. Check switch to ensure positive interlock between normal and alternate sources.
      d. Check tightness of all cable connections and bus joints.
      e. Perform manual transfer operations.
      f. Electrical Tests for Automatic Transfer Switch:
         1) Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.
         2) Set and calibrate in accordance with the Manufacturer's recommendations.
            (a) Voltage-sensing relays.
            (b) Transfer time delay relays.
            (c) Engine shutdown relays.
         3) Perform automatic transfer by:
            (a) Simulating loss of normal power.
            (b) Return to normal power.
         4) Monitor and verify correct operation and timing:
            (a) Normal voltage-sensing relays.
            (b) Engine start sequence.
            (c) Time delay upon transfer.
            (d) Alternate voltage-sensing relays.
            (e) Automatic transfer operation.
            (f) Interlocks and limit switch function.
            (g) Timing delay and retransfer upon normal power restoration.
            (h) Engine shutdown feature.
            (i) Correct functioning of auto-exercising controller.

D. Maintenance and operating instruction manuals. Submit four bound copies including approved Shop Drawings, parts list, list of recommended spare parts, sources of purchase and similar information.

1.3 REFERENCE STANDARDS

A. The following Specifications and standards, except as hereinafter modified, are incorporated herein by reference and form a part of this Specification to extend the indicated by the references thereto. Except where specific date is given, issue in effect (including amendments, addenda, revisions, supplements, and errata) on the bid date shall be applicable. In text such Specifications and standards are referred to by basic designation only.

B. National Fire Protection Association (NFPA)
   1. No. 70 National Electrical Code (NEC)

C. Underwriters' Laboratories, Inc. (UL):
   1. No. 1008 Automatic Transfer Switches
   2. No. 489 Molded Case Circuit Breakers

D. National Electrical Manufacturers Association (NEMA):
   1. ICS 2.447 Industrial Control and Systems

E. American National Standards Institute (ANSI):
   1. V37-90a Guide for Surge Withstand Capability (SWC) Tests

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. ASCO

B. Russelectric

C. Onan

D. Kohler

E. Caterpillar

2.2 AUTOMATIC TRANSFER SWITCH, GENERAL

A. Each automatic transfer switch (ATS) shall be 3-pole or 4-pole as indicated on the drawings and rated as indicated on the drawings. Transfer switch shall be listed and labeled under UL-1008 as a device for use on emergency generator systems. ATS shall be mounted in a Nema 1 or Nema 3R enclosure as indicated on the drawings. ATS shall be the standard product of a company engaged in manufacturing automatic transfer switches for at least 10 years. ATS shall be manufactured so that no rear or side access is required.

2.3 CONSTRUCTION AND PERFORMANCE

A. Transfer Switch shall consist of completely enclosed multi- pole contact assembly and a separate control logic panel. The contact assemblies shall be operated by a stored energy mechanism, and be energized only momentarily during transfer providing inherently double throw switching action. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

B. Transfer Switch shall be positively interlocked mechanically and electrically to prevent simultaneous closing of both sources under either automatic or manual operation. A neutral position shall not be possible under normal electrical operation except that the switch shall be

provided with a Delayed Transition accessory for switching highly inductive loads. Transfer Switch shall have a manual neutral position for load circuit maintenance. A Transfer Switch position indicator shall be visible from the front of the switch to show to which source the transfer switch is connected.

C. Transfer switch shall be capable of being operated manually under full load conditions. Manual operation shall be accomplished via integrally mounted pushbutton operators located on the face of the contact assemblies. Removable manual operation handles and handles which will move in the event the electrical operator becomes energized while performing a manual transfer operation are not acceptable. The manual operator shall provide the same contact-to-contact transfer time as provided under normal automatic operation to prevent possible flashovers from switching the main contacts slowly. In addition, provisions shall be provided to allow disengagement of the electrical operator during manual operation.

D. Transfer Switch shall have four extra sets of normally open and normally closed auxiliary contacts, which indicate ATS positions.

E. A solid state sensing and control logic panel shall be separately mounted from the power-switching portion of the Transfer Switch. The two Sections shall be connected together by control cables with plug-in connectors. The control Section shall be capable of being disconnected from the power Section for maintenance purposes.

F. The logic circuit shall utilize differential sensing solid-state components mounted on printed circuit boards to accomplish proper operation and to perform functions such as timing and voltage and frequency monitoring. LED's on each PC card shall indicate the proper operation of each function furnished. Construction shall be such that functions cards are individually replaceable without requiring replacement of the complete solid-state package. Cards for plug-in modifications shall be available for field installation with retention of the UL label.

G. Where indicated on the drawings, ATS shall be provided with power meter, Square D PM850 or equal, with network card for communications interface with Owner’s power management system.

2.4 SEQUENCE OF OPERATION

A. Upon reduction of phase-to-phase voltage of the normal source to 80% of nominal, and after a time delay of 1-90 seconds (adjustable to meet field conditions) to override momentary dips and/or outages, the auxiliary engine start contacts shall close to initiate starting of the Emergency Generator.

B. After the Generator has reached 90% of nominal voltage and frequency, and after a time delay, ATS shall transfer the load to the Generator. Provide an under-voltage / under-frequency monitor for the Emergency/Standby Source.

C. When the Normal Source has been restored to 90% of rated voltage, and after a time delay adjustable from 0.5-30 minutes (to insure the integrity of the Normal Power Source), the load shall be retransferred to the Normal Source.

D. A time delay module shall be provided in the ATS, adjustable 0.5-30 minutes, to delay shutdown of the Emergency/Standby Power Source after retransfers to allow the generator to run unloaded for cool-down.

E. If the Emergency Generator should fail while carrying the load, transfer to the Normal Power supply shall be made instantaneously upon restoration of the Normal Source to satisfactory conditions.

F. ATS shall be provided with a Delayed Transition timer, adjustable 0-120 seconds. The ATS shall pause during transfer with both sources disconnected from the load, to allow back-EMF from large inductive loads to decay. Methods, which use relative phase-angle differences to control transfer, are not acceptable.

G. ATS shall be provided with 4 sets of Auxiliary Contacts to indicate 'Normal' or 'Emergency' Position of the ATS.

2.5 ADDITIONAL ACCESSORIES/SPARE PARTS

A. Provide an engine exercise timer in the ATS indicated on the drawings which shall automatically start the engine periodically. Timer shall be digital, with lithium battery back up. Provide a selector switch to select exercise with load transfer or without load transfer. The timer shall include a failsafe circuit, such that if the engine fails during exercise the ATS will immediately retransfer to the Normal source.

B. Provide pilot lights to indicate to which source the load is connected, and to indicate the availability of each power source.

C. The transfer switch shall be rated for the short circuit currents noted on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Section 260500 for details of Work under this Section, including seismic installation requirements.

B. Testing: See Section 260800 and Section 263214.

END OF SECTION

SECTION 265101
LIGHTING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Luminaires (i.e., lighting fixtures): Refer to the Luminaire Schedule and provide a complete and working facility Lighting System. Catalog numbers in the Luminaire Schedule are design series references and may not represent the exact catalog number as specified or as required for particular installations. Provide complete luminaires to correspond with the number of LEDs, power supply, wattage, mounting hardware, ceiling type, trim, size, and special requirements as specified in the Luminaire Schedule for each luminaire type. Additional features, accessories, and options specified, described, scheduled, or necessary for installation shall be included.

B. LEDs and power supplies.

C. Lighting controls, including occupancy sensors. See Section 265700 for Low Voltage Lighting Control System.

D. Exit and Emergency Egress lighting where indicated and where required.

E. Supports for outlet boxes and luminaires, including seismic restraint slack wires for recessed luminaires in suspended ceilings per code and backing in walls as required to keep luminaires secure and level.

1.2 INCORPORATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this section.

B. Section 260500 and 262700 apply to all work in this section.

C. Division 03: Concrete (Bases for pole-mounted luminaires as noted in Luminaire Schedule).

D. Division 09: Painting and Finishes (cutting of holes in finished surfaces for recessed luminaires).

1.3 RELATED WORK

A. Ceiling Access panels where required for access to equipment, outlets, transformers, etc., located above suspended ceilings, sheet rock or plaster ceilings. Coordinate with the Architect and other trades.

1.4 SUBMITTALS

A. Submit under provisions of Division 1 and Section 260500.

B. Submit (6) six sets of submittals for review by the project team unless otherwise noted in these specifications. The submittals shall include the following information:
   1. Product Index: The following information shall be included in the product index.
      a. Luminaire Type. The index shall list, in alphabetical order, each luminaire type per the Luminaire Schedule.
      b. Manufacturer’s Catalog Number. Outstanding information required to make a complete catalog number shall be clearly identified in the index.

c. Where a pole is included with the luminaire, include the catalog number of the pole in addition to that of the luminaire.
d. LED Data. Provide the Manufacturer's name for each LED array including wattage, color temperature, lumen output, and color rendering index.

2. Manufacturer's literature for every luminaire listed on the Luminaire Schedule.
   a. Catalog Information:
      1) Luminaire Data Sheet: The manufacturer's cut sheet shall include the following:
         (a) Photometrics: Candlepower distribution curve or table with horizontal readings at 0, 22.5, 45, and 90 degrees and vertical readings from 0 to 180 degrees in 5 degree increments in accordance with the Illuminating Engineering Society published test procedures.
         (b) Catalog Number Nomenclature
         (c) Coefficient of Utilization Tables
         (d) Luminaire Line Drawing
         (e) Power supply (each type)
3. Data sheets for power supplies. Indicate luminaire types on applicable power supply data sheets.
4. Data sheets for wallbox controls and other products specified in this section.
5. Shop Drawings:
   a. Provide shop drawings of suspension details for luminaires recessed in, mounted on, or suspended from hung ceilings. Details shall clearly illustrate proposed methods for supporting luminaires independent of the suspended ceiling system.
   b. Detailed shop drawings of all cove or box mounted luminaires containing the following information:
      1) Exact field measured length (clear inside dimension) of cove pocket or box.
      2) Exact luminaire length and arrangement of luminaires in cove or box.
   c. Detailed shop drawings of pendant mounted luminaires constructed with linear metal housings containing the following information.
      1) Support mechanism, including swivel canopies.
      2) Trim details.
      3) Closure piece details.
      4) Pattern configurations.
6. Samples:
   a. Provide samples of luminaire trim where "Finish as selected by Architect" is indicated on the Luminaire Schedule. Submit two finish samples, 75 mm x 75 mm (3" x 3") minimum, of all custom color, decorative metal, or anodized aluminum finishes. Samples must be approved in writing by the Architect prior to ordering.
   b. Submit sample of custom luminaires: complete and operational, equipped with 120V, 6 foot cord and 3 prong grounded plug. Luminaire shall be fabricated and finished as specified, full size, using specified materials & equipment. Submit one luminaire to Owner's representative for review prior to production.

C. For Any Luminaires Substituted For Those Specified:
1. Refer to Division 1 - Product Requirements, for all substitution procedures.
2. Provide independent testing laboratories, Inc., or equal, photometric test report for each Luminaire type and lamp combination listed on the Luminaire Schedule. Test reports shall be based on Illuminating Engineering Society published test procedures and shall contain polar coordinate candlepower distribution curves in five lateral planes for luminaires with asymmetric distributions and luminaire luminance data for vertical angles above 45 degrees from nadir. Test results shall indicate luminaire efficiency for the lamp and aperture assembly specified. luminaires with efficiencies more than 2% below the values of specified luminaires are not acceptable and will be rejected.
3. Provide photometric calculations for each room or area where a substituted luminaire is proposed. Such calculations shall be made using comprehensive lighting software, such as AGi32, and include point-by-point illuminance values at IES recommended heights,

average illuminance, and maximum-to-minimum and average-to-minimum uniformity ratios. Room dimensions, configurations (including sloping ceilings), room surface reflectances, light loss factors, and heights of suspended luminaires shall match the heights specified in the contract documents.

4. Due to the variety of lumen outputs and light distributions of LED Luminaires, substitutions will require additional review on the part of the Engineer or Architect to ascertain the equivalency of the substituted luminaires. Substitutions will be reviewed to determine their aesthetic, construction, and photometric equivalency to maintain similar design impact and performance in their intended environment. The Engineer and Architect have not included such unknown and unquantifiable review time in their scope of work and are not compensated by the Owner for such services. The Contractor shall reimburse the Engineer and Architect for labor costs to review substitutions.
5. Prior approval does not guarantee final approval by the Engineer. The Contractor shall be responsible for providing luminaires that meet or exceed the quality and performance of the specified products in their entirety. All deviations in quality and performance from the specified products must be listed and individually signed off by the engineer.
6. The Owner reserves the right to reject a proposed substitution based on their agent’s professional judgment as to the utility, quality, performance, visual appropriateness, or finish of substitutions.

1.5 OCCUPANCY SENSORS

A. Equipment Qualification
   1. Wall switch products must be capable of withstanding the effects of inrush current. Submittals shall clearly indicate the method used.
   2. Contractor's work to include all labor, materials, tools, appliances, control hardware, sensor, wire, junction boxes and equipment necessary for and incidental to the delivery, installation and furnishing of a completely operational occupancy sensor lighting control system, as described herein.
   3. Contractor and Contractor's Supplier shall examine all general specification provisions and drawings for related electrical work required as work under Division 26.
   4. Contractor shall coordinate all work described in this section with all other applicable plans and specifications, including but not limited to wiring, conduit, luminaires, HVAC systems and building management systems.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site and store in unopened cartons in protected location. Inspect products immediately and report all damage accordingly.

1.7 GUARANTEE AND WARRANTIES

A. All work performed under this section must be guaranteed to be free of defects in products or workmanship for one year after date of acceptance by Owner, unless noted otherwise in General Conditions.

B. Warranties:
   1. Electronic power supplies must be warranted against failure for at least five years after date of substantial completion.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide luminaires as indicated in Luminaire Schedule; if conflict exists between Luminaire Schedule and Specifications, the more stringent requirement shall take precedence.

B. Provide luminaires new and complete with mounting accessories, junction boxes, trims, and lamps.

C. Provide products with UL labels appropriate to intended installation conditions, or with labels from other testing laboratories whose results are acceptable to local inspector, showing compliance with UL standards. Labels must be concealed from normal viewing angles.

D. All products of same type by same manufacturer.

2.2 SOLID STATE LUMINAIRES

A. Housing, where applicable:
   1. Steel bonderized or equal rust protected, or aluminum, rigid construction. Minimum gauge thickness shall be as follows:
      a. Interior locations: No. 20-gauge steel, No. 16-gauge aluminum.

B. Finish:
   1. Baked enamel finish (except when otherwise specified).
      a. Concealed interior surfaces (this applies to interior hardware, circuit boards, etc.) matte black.
      b. Concealed exterior surfaces: matte black.
      c. Visible surfaces: color and texture as specified below for each luminaire type or as selected.

C. Light Emitting Diode (LED) requirements:
   1. Correlated color temperature (CCT) for phosphor-coated white LEDs must have one of the following designated CCTs, as specified on the Luminaire Schedule, and fall within the following binning standards.
      a. 3000K defined as 3045 +/- 175K
      b. 3500K defined as 3465 +/- 245K
      c. 4000K defined as 3985 +/- 275K
   2. Color spatial uniformity shall be limited to variations in chromaticity for different directions (i.e. changes in viewing angle) within 0.004 from the weighted average point on the CIE 1976 (u',v') diagram.
   3. Color maintenance shall be limited to a maximum change in chromaticity of 0.007 on the CIE 1976 (u',v') diagram over the lifetime of the product.
      a. Color rendering index: Color rendering index to be determined using ANSI C78.377-2008 and applicable IESNA standards.
      b. Laboratory tests must be produced using specific module(s)/array(s) and power supply combination that will be used in production.
      c. Manufacturers must provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories
   4. Lumen depreciation
      a. Lumen depreciation to be measured using IESNA LM-80-08 and TM-21-11 standard for IES approved method of measuring lumen maintenance of LED light sources.
      b. Phosphor-coated white LED modules/arrays shall deliver at least 70% of initial lumens for a minimum of 50,000 hours when installed in-situ and operated at 100% output and the maximum specified operating temperature.

c. Colored LED modules/arrays shall deliver at least 50% of initial lumens for a minimum of 50,000 hours when installed in-situ and operated at 100% output and the maximum specified operating temperature.

5. Acceptable LED manufacturers:
   a. Cree
   b. Nichia
   c. Osram Opto Semiconductors
   d. Philips Lumileds
   e. Soraa
   f. Xicato

D. Luminaire Efficacy:
   1. Luminaire efficiency shall be measured using IESNA LM-79-08 standard for electrical and photometric measurements of solid state lighting products.
   2. Manufacturer shall provide published luminaire efficacy, which is defined as luminaire light output divided by luminaire input power measured in a 25 degree Celsius environment. Efficacy shall include power supply, thermal, optical, and luminaire losses.

E. Thermal Management:
   1. Solid state luminaire shall not exceed LED manufacturer's maximum junction temperature requirements when operated in-situ at luminaire manufacturer's maximum ambient operating temperature and 100% light output.
   2. Solid state luminaires shall be thermally protected using one or more of the following thermal management techniques:
      a. Metal core board
      b. Gap pad
      c. Internal monitoring firmware
   3. Solid state luminaire housing shall be designed to transfer heat from the LED board to the outside environment.

F. Power Supplies (LED Drivers) requirements:
   1. Power factor of 0.90 or greater for primary application
   2. Input current shall have Total Harmonic Distortion (THD) of less than 20%.
   3. Minimum operating temperature of minus 20 degrees Celsius or below when used in luminaires intended for outdoor applications.
   4. Operating frequency equal to or greater than 120 Hz.
   5. Operate with sustained input variations of +/- 10% (voltage and frequency) with no damage to the driver.
   6. Tolerate sustained open circuit and short circuit output conditions without damage and without need for external fuses or trip devices.
   7. Output shall be regulated to +/- 5% across published load range.
   8. Class A sound rating.
   9. Outputs shall have current limiting protection.
   10. Operate LEDs at constant and regulated current levels. LEDs shall not be overdriven beyond the diode manufacturer's specified nominal voltage and current.

G. Solid State Lighting Controls:
   1. Control interface to dimmable power supplies shall consist of one of the following:
      a. Line Voltage Dimming. Controls to be rated for magnetic or electronic low voltage transformer operation.
      b. Low voltage (0-10V) control. Controls to be compatible with either current sink or current source operation.
      c. DMX control
   2. Dimmable LED power supplies shall use pulse width modulation (PWM) or constant current reduction (CCR) to regulate power to LEDs.

a. PWM power supplies shall have 12-bit or greater resolution to obtain flicker-free operation throughout their dimming range.
b. PWM power supplies shall be provided in luminaires that will be dimmed lower than 40% and must maintain consistent color temperature.
c. CCR power supplies shall be provided in areas that have strict electromagnetic interference (EMI) requirements, high motion activity, or rotating machinery.

H. System Installation
1. Hardwired connections to solid state luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
2. All solid state luminaires (100% of each lot) shall undergo a minimum eight-hour burn-in test during manufacturing. Solid state lighting installations shall be UL Listed as a low-voltage lighting system including, but not limited to, luminaire, power supply, controller, keypad, and wiring.

I. Warranty
1. Luminaires, drivers, and controllers for solid state lighting systems shall be covered by a five-year warranty against defects in workmanship or material. Warranty shall include in-warranty service program providing for payment of authorized labor charges incurred in replacement of inoperative in-warranty equipment.

2.3 LUMINAIRE CONSTRUCTION

A. Sheet metal: materials and thicknesses shall be 20 gauge (0.7 mm or 0.027") min., free of dents, scratches, oil-can, or other defects.

B. Painted luminaires: exposed weld marks, joints, and seams shall be filled and sanded smooth before finishing.

C. All edges cleaned and dressed to remove sharp edges or burrs.

D. Extrusions: 1/10" min. wall thickness, smooth and free of tooling lines, with cast end plates that exactly match extrusion profiles.

E. Castings: smooth, free of pits, scales, gate marks, or blemishes.

F. Spinnings shall have 1/32" min. thickness, smooth, free of spinning lines or blow-back, with clean edges.

G. Welds: Follow recommendations of American Welding Society. All welds continuous and free of spatter, residue, or warping.

H. No light leaks visible in finished room. Ensure that downlight housings mounted in wood slat ceilings are not visible from below. Field paint exterior of housing with high temperature paint if necessary.

I. Exposed end plates and joiners, with concealed fasteners.

J. End-to-end mounted luminaires: Verify row configurations and provide joiners, aligning splines, and trims to suit.

K. Hardware:
1. Steel or aluminum interior luminaires: cadmium-plated hardware.
2. Steel or aluminum exterior luminaires: stainless steel hardware.
3. Stainless steel luminaires: stainless steel hardware.

4. Copper alloy luminaires: brass hardware.

L. Raceways: Where used for through wiring, luminaires must be approved for use as raceways.

2.4 RECESSED LUMINAIRES

A. Point-source luminaires: provide pre-wired junction box and thermal protection, and provide slack wires to structure at two diagonal corners.

B. Troffer-type and flat panel luminaires: provide hold-down clips and slack wires to structure as detailed on the drawings. The detail will take precedence.

C. Verify ceiling construction details and provide luminaire housings and trims to suit.

D. Non-accessible ceilings: Provide access to junction boxes, ballasts, transformers, and battery packs through luminaire apertures; no access panels in ceiling.

E. Mounting frames: To prevent rusting, provide galvanized steel or cast aluminum frames for installation in damp locations or in plaster ceilings.

F. Adjustable luminaires shall be provided with rotation and tilt locking devices.

2.5 PENDANTS

A. Stem-mounted: 16 mm (5/8") max. o.d. stem with ball swivels at top (and bottom of linear luminaires) to permit 45 degree swing in any direction from vertical. Flat canopy to permit splice inspection after installation. Pendants must permit +/- 13 mm (½") threaded vertical adjustment after installation, leaving at least 6 mm (1/4") thread contact at all points.

B. Provide internal safety cable from luminaire body to stud in outlet box.

C. Cable-mounted: 1 X 7 strand 3/32" diameter stainless steel aircraft cable, factory crimped, independently tested and verified to exceed 1500 pounds.
   1. Verify mounting heights for each luminaire and provide cable lengths and coordinate cord lengths with manufacturer as required prior to ordering luminaires. Provide aircraft cable adjuster nipple with locking jaws.

D. Supports: Carry luminaire weight to structure and provide horizontal bracing from suspension points to ceiling framing to prevent sideways shifting. Provide diagonal seismic restraint wires per code.

2.6 TRIMS

A. Trims must fit tightly and be held in by gravity, spring clips, or mechanical fasteners. Trims must not drop out under normal conditions or seismic forces which do not exceed the design criteria of the building.

B. Aluminum parabolic cones shall be smooth, properly shaped, with Alzak finish in colors as indicated.
   1. No hot spots or lamp images visible at angles shallower than lamp shielding angle.
   2. Self-flange cones must bend parallel to ceiling and cover ceiling hole without additional trim ring. Unpainted flange, shall have the same finish as cone interior.
   3. Cones and louvers for fluorescent luminaires must have permanent anti-iridescence treatment.

C. Lenses, diffusers, and patterned glass: glass or virgin acrylic as noted, with patterns as noted.

1. Finished thickness 2 mm (1/10") min. unless noted otherwise.
2. Linear runs over 1200 mm (4'-0") long shall be in equal-length pieces.

2.7 FINISHES

A. Steel Reflectors: Unless otherwise specified, the reflector surface finish shall be of synthetic white enamel or polyester powder coating. Finish shall show no indication of chipping, cracking, flaking or any other sign of loss of adhesion. The initial reflection factor shall be not less than 88 percent averaging 5 randomly selected points on the reflector. After 100 hours of exposure to the radiation of a glass enclosed carbon arc lamp, such as a Fade-O-Meters, the reflectance of the exposed portion shall not be less than 5 percent and finish shall show no appreciable color change. The carbon arc lamp shall be operated at appreciable color change. The carbon arc lamp shall be operated at 13 plus or minus 0.5 amperes at 140 volts. The reflector shall be placed ten inches from the arc and the lamp so ventilated that the temperature of the exposed portion does not exceed 105 degrees F.

B. Aluminum Reflectors: Reflecting surfaces shall be provided with either a specular or diffuse finish as indicated. Reflection factors shall be not less than 83 percent for specular reflecting surfaces. Each reflecting surface shall be protected by dense coating of oxide weighing not less than 5.0 milligrams per square inch, applied by an anodic process. The reflector shall be given a sealing treatment that will prevent staining of the reflecting surface when subjected to a stain test. All aluminum reflectors & louvers shall be a low iridescent equivalent to that provided by Coil Anodizers.

C. Non-Reflecting Surfaces: Unless otherwise specified, the finish on all non-reflecting exterior surfaces shall be aluminum oxide or aluminum; white, gray or aluminum paint on steel; nickel or chromium plating on copper alloy. Fastening devices shall be nickel, chromium, cadmium or zinc plated. All painted surfaces shall be free of tears, star marks, blisters, pinholes, chipping and any other defects that may impair appearance or serviceability.

2.8 LAMPS

A. Relamp luminaires or replace LED boards and power supplies at no cost to owner if lamps or LEDs exhibit color variation, flicker, or burn out within 90 days of substantial completion date.

B. LEDs:
1. LED quantity, wattage, and color temperature as specified for each LED luminaire.
2. 3500 deg. K color temperature for interior luminaires, 3000 deg. K for exterior luminaires, unless otherwise specified.

2.9 DRIVERS AND TRANSFORMERS

A. General:
1. Verify input voltages and match to branch circuit voltages.
2. Remote drivers or transformers: Provide suitable enclosures and mounting hardware, and install in accessible, ventilated locations.
    a. Secondary wiring: provide number and size of conductors as required, with 3% max. voltage drop between transformer and last lamp.
    b. Keep transformers at least 300 mm (12”) apart and do not stack vertically.

B. LED Drivers:
1. High power factor, thermally-protected.
2. Compatible with LED lamps being used.
3. Capable of dimming LED source without perceptible flicker or stroboscopic effects.

2.10 EMERGENCY LIGHTING AND EXIT SIGNS

A. Emergency lighting:
   1. Provide lighting for paths of egress as required by Code.

B. Emergency lighting to consist of wall or ceiling mounted (normally off) lamp head units with battery back-up for 90 minutes of egress lighting output.

C. Description of Systems:
   1. Auxiliary battery packs mounted integral to luminaires shall provide no less than 1400 lumen output for a minimum of 90 minutes.
   2. Surface mounted luminaire with two (2) reflector-type LED lamps on emergency battery with 90 minute operation.

D. Auxiliary Battery Pack/Ballasts for LED Luminaires:
   1. Pure lead or nickel-cadmium, sealed and maintenance-free.
   2. Automatic transfer to battery power if supply voltage drops below 75% of normal.
   3. Must provide at least 87-1/2% or rated battery voltage for 90 minutes minimum.
   4. Internal circuitry to provide continuous “trickle” charge and to prevent deep discharge below 80% of rated battery voltage.
   5. Full recharge within 24 hours after restoration of normal power.
   6. Charge indicator light visible and test switch operable without tools.
   7. Concealed inside luminaire or above ceiling, but replaceable through luminaire aperture.
   8. Designed to run one or two lamps per luminaire with minimum of 1400 lumen output.
   9. Acceptable manufacturers: Bodine, Dual-Lite, Emergi-Lite, Lithonia, Radiant, Siltron.

E. Recessed emergency luminaire:
   1. Cold rolled steel housing.
   2. 12v sealed permanent magnet type motor with 30 yr. Service life.
   3. Solid state electronics.
   4. Integral test switch and pilot light to indicate charge rate.
   5. Acceptable manufacturers: Concealite.

F. Exit signs shall be edge or back lit LED, surface-mounted on ceiling or wall, with integral battery packs as described above.
   1. Fabricated aluminum construction, no light leaks around canopy. Plain box, with no decorative trim.
   2. Letters shall be 20mm (3/4”) stroke, 150 mm (6”) high, with concealed knockouts for left or right arrows, brightness and evenness of illumination per code, green color.
      a. Battery pack contained in basic luminaire housing. No add-on packs or canopies.
      b. Green LED lamps located at interior perimeter for indirect illumination of stencil letters.
      c. Provide finish as specified in the Luminaire Schedule.
      d. Knock out the arrows as indicated on the plans.

G. Emergency luminaires supplied by a separate emergency power source.
   1. For luminaires supplied by a separate emergency power source, provide "switched" control of the emergency designated lamps to allow complete "off" control when required by the user. The switched control shall include an automatic transfer feature to automatically turn "on" the emergency designated lamps upon the normal source power failure.
   2. Automatic transfer function shall be provided using a UL 924 listed relay, LVS Inc. #EPC-A or equal, suitable for mounting in a standard 4" square j-box (min. 2.5" deep). Transfer relay shall provide automatic diagnostic test feature which shall maintain power to the emergency designated lamps for 15 seconds after the room is switched off via the

respective light switch or control relay. Emergency designated lamps shall turn off after the 15 second test period and shall come back on when the control device is turned back on to restore full lighting to the space.

3. Provide (1) transfer module per "switched" zone.

H. Emergency luminaires supplied by a dimmer panel and/or emergency source.
   1. For luminaires supplied by a dimmed power source, provide "dimmed" control of the emergency designated lamps to allow normal dimming control with the normal lamps. The dimmed control shall include an automatic transfer feature to automatically turn "on" the dimmed lamps to full light output upon the normal source power failure.
   2. Automatic transfer function shall be provided using a UL 924 listed relay, LVS Inc. #EPC-D (2-wire dimmed), #EPC-D-U (3-wired dimmed) or equal, suitable for mounting in a standard 4" square j-box (min. 2.5" deep).
   3. Provide (1) transfer module per "dimmed" zone.
   4. For DMX-controlled LED emergency lighting, provide control bypass, ETC DEBC series with emergency bypass detection kit - quantity of DEBC outputs as indicated on drawings.

2.11 WALL-BOX DIMMERS

A. Provide dimmer controls as specified on the drawings and in Specifications Section 26 57 00.

B. Ganging and Labeling:
   1. Labels: text as indicated 3 mm (1/8”) high, all capital letters, engraved on device faceplate, filled with black paint and wiped clean.

2.12 OCCUPANCY SENSORS

A. General
   1. Wall switch sensors shall be capable of detection of occupancy at desktop level up to 300 square feet, and gross motion up to 1000 square feet.
   2. Wall switch sensors shall accommodate loads from 0 to 800 watts at 120 volts; 0 to 1200 watts at 277 volts and shall have 180° coverage capability.
   3. Wall switch products shall utilize Zero Crossing Circuitry which increases relay life, protects from the effects of inrush current, and increases sensor’s longevity.
   4. Wall switch sensors shall have no leakage current to load, in manual or in Auto/Off mode for safety purposes and shall have voltage drop protection.
   5. Where specified, wall switch sensors shall provide a field selectable option to convert sensor operation from automatic-ON to manual-ON.
   6. Where specified, vandal resistant wall switch sensors shall utilize a hard lens with a minimum 1.0mm thickness. Products utilizing a soft lens will not be considered.
   7. Passive infrared sensors shall utilize Pulse Count Processing and Digital Signature Analysis to respond only to those signals caused by human motion.
   8. Passive infrared sensors shall utilize mixed signal ASIC which provides high immunity to false triggering from RFI (hand-held radios) and EMI (electrical noise on the line), superior performance, and greater reliability.
   9. Passive infrared sensors shall have a multiple segmented Lodif Fresnel lens, in a multiple-tier configuration, with grooves-in to eliminate dust and residue build-up.
   10. Where specified, passive infrared and dual technology sensors shall offer daylighting foot-candle adjustment control and be able to accommodate dual level lighting.
   11. Dual technology sensors shall be corner mounted to avoid detection outside the controlled area when doors are left open.
   12. Dual technology sensors shall consist of passive infrared and ultrasonic technologies for occupancy detection. Products that react to noise or ambient sound shall not be considered.

13. Ultrasonic sensors shall utilize Advanced Signal Processing to adjust the detection threshold dynamically to compensate for constantly changing levels of activity and air flow throughout controlled space.
14. Ultrasonic operating frequency shall be crystal controlled at 25 kHz within ± 0.005% tolerance, 32 kHz within ± 0.002% tolerance, or 40 kHz ± 0.002% tolerance to assure reliable performance and eliminate sensor cross-talk. Sensors using multiple frequencies are not acceptable.
15. All sensors shall be capable of operating normally with electronic ballasts, PL lamp systems and rated motor loads.
16. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to the cycling of air conditioner or heating fans.
17. All sensors shall have readily accessible, user adjustable settings for time delay and sensitivity. Settings shall be located on the sensor (not the control unit) and shall be recessed to limit tampering.
18. In the event of failure, a bypass manual override shall be provided on each sensor. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. This control shall be recessed to prevent tampering.
19. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
20. Where specified, sensor shall have an internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options. Sensors utilizing separate components or specially modified units to achieve this function are not acceptable.
21. All sensors shall have UL rated, 94V-0 plastic enclosures.

B. Circuit Control Hardware - CU
    1. Control Units - For ease of mounting, installation and future service, control unit(s) shall be able to externally mount through a 1/2" knock-out on a standard electrical enclosure and be an integrated, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Control unit shall provide power to a minimum of two (2) sensors.
    2. Relay Contacts shall have ratings of:
        a. 13A - 120 VAC Tungsten
        b. 20A - 120 VAC Ballast
        c. 20A - 277 VAC Ballast
    3. Control wiring between sensors and controls units shall be Class II, 18-24 AWG, stranded U.L. Classified, PVC insulated or TEFLON jacketed cable suitable for use in plenums, where applicable.
    4. Minimum acceptable wire gauge from the circuit control hardware relays shall be #14 AWG.

C. Acceptable Manufacturers
    1. The Watt Stopper, or Pre-Approved Equal: For pre-approval, provide all the information listed under “submittals” a minimum of ten (10) working days prior to initial bid date.
    2. The listing of any manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any price quotations received and submittals made are for sensors that meet or exceed the specifications and the requirements of the contract documents.

PART 3 - EXECUTION

3.1 PREPARATION

A. Architectural Reflected Ceiling Plans and Elevations shall govern exact location and mounting conditions for all luminaires. Contractor shall coordinate luminaire mounting and compatibility with ceiling construction and other trades.

B. Coordinate work with other trades. Location of lighting has priority over location of new framing (except major structural members), ducts, diffusers, sprinklers, speakers, smoke detectors, and other obstructions.

C. If obstructions are encountered which prevent installation of luminaires according to drawings, notify Architect immediately and do not proceed until conflict has been resolved.

D. Coordinate the location of luminaires in mechanical or unfinished spaces. Locations shown on Drawings may be adjusted by the Contractor to suit conditions. Install luminaires to avoid obstructions and maximize light output, 2100 mm (7'-0") min. mounting height.

E. In Elevator Machine Rooms, locate the luminaires so that the illumination level at the floor is not less than 200 lx (19 fc). Illuminate areas in front of and behind (if accessible) controllers, machines and other elevator equipment.

F. In Elevator Pits, locate the luminaires so that the illumination level at the pit floor is not less than 100 lx (10 fc).

G. Coordinate the location of any exposed conduit used to feed luminaires with the Architect prior to installation.

3.2 INSTALLATION

A. General:
   1. Contractor shall be responsible for handling and installation of luminaires including all supports, hangers and hardware necessary for a complete installation. Luminaires shall be clean, plumb, level in straight lines, without distortion. Luminaires must be installed so they do not shift during relamping or adjustment. Remedy any light leaks which may develop after installation of recessed or enclosed luminaires.
   2. Install luminaires at locations and heights as indicated, in accordance with luminaire manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that luminaires fulfill requirements.
   3. Point-source luminaires shall be located as dimensioned, or in center of tile or on tile joint as drawn; 6 mm (1/4") max. off-center tolerance.
   4. Linear luminaires shall have 3 mm (1/8") max. horizontal or vertical alignment variation in any 5 m (16-ft.) portion of run.
   5. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds. 486 A and B, and the National Electrical Code.
   6. Clean luminaires of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses.
   7. Remove and replace luminaires that may have been damaged during construction at no additional cost to the Owner.
   8. Protect installed luminaires from damage during remainder of construction period.

9. Provide equipment grounding connections for luminaires as indicated. Tighten connections to comply with tightening torques specified in UL 486 A to assure permanent and effective grounds.
10. Install luminaires, lamps, lenses, etc., after building is enclosed, weather tight and environmental conditions are nominally the same as expected for the complete spaces. All lenses, glass, reflectors, and refractors shall be clean and free of chips, cracks, and scratches.
11. All wall mounted luminaires and all ceiling mounted surface luminaires including exit lights shall be fed through a luminaire Stud/Hickey/Nipple assembly and with provisions to prevent luminaire turning.
12. Installation of exit signs shall be coordinated with other trades to ensure signs are visible as intended.
13. All junction box cover plates for the lighting branch circuit system shall be clearly marked with a permanent ink felt pen identifying the branch circuit and control relay (panel number, circuit number, lighting control cabinet designation and control relay number) contained in the box.
14. Provide permanently affixed adhesive labels with machine printed lettering (min. 1/8" high) at junction boxes serving luminaires that are supplied by (2) electrical sources (i.e. normal and emergency lighting). Label to read "CAUTION - This luminaire is powered by (2) separate sources. The normal power source breaker and the emergency power source breaker must be turned off before servicing this luminaire."

B. Recessed Luminaires:
1. The contractor shall verify the fire rating of the ceiling system and wall in which the luminaires are to be mounted. Where luminaires are installed in fire rated ceilings or walls, provide fire rated enclosures around and over luminaires to maintain ceiling fire rating. No additional cost shall be allowed for failure to include such enclosures and installation in the bid.
2. Holes for Recessed Point-Source Luminaires: Cut holes to follow luminaire housings exactly so no gaps will be visible after trims are installed.
3. Install bottom of housing aligned with finished ceiling.
4. Keep ceiling insulation at least 75 mm (3") away from luminaires. Exception: luminaires with insulated contact (IC) rating shall be permitted to be in contact with insulation.
5. Install trims after painting of spaces. Install trims tightly, with no gaps or light leaks.
6. Seismic restraints: Provide and install slack wires and hold-down clips per code.
7. Wallwashers:
    a. Orient wallwasher housings according to manufacturer’s instructions to maximize brightness on the upper portion of the wall.

C. Ceiling-Mounted and Pendant Luminaires:
1. Provide support for outlet boxes and suspension points so luminaires can be installed securely, including seismic supports per code.
    a. Luminaire weight less than 23 kg (50 lb) at each suspension point: hang from strap or stud on outlet box, or at non-feed points, provide 1/4"-20 stud projecting 20 mm (3/4") below ceiling.
    b. Luminaire weight 23 kg (50 lb) or more at each suspension point: hang directly from structure, either independent of outlet box or from stud extending through outlet box to structure, unless the outlet box is listed for not less than the weight to be supported. Boxes used as the sole support of luminaires weighing more than 50 pounds must be listed and marked by the manufacturer with the maximum weight.
2. Pendants:
    a. Provide horizontal bracing from suspension points to ceiling framing to prevent sideways shifting.
    b. Provide diagonal seismic restraint wires above ceiling per code.

c. Furnish suspended luminaires with universal joint type hanger canopy (and longitudinal sway adapter at each stem connection point for linear luminaires), to permit 45 degree swivel on 360 degree circle from Nadir at canopy (and 45 degree longitudinal movement at sway adapter).
d. Luminaires over 450 mm (18") wide shall be provided with supports at all corners.
e. Install pendants plumb and level.
f. Verify luminaire weights and provide backing in ceiling as required.

D. Wall-Mounted Luminaires:
1. Mounting heights shown on Drawings are measured from finished floor to centerline of outlet box or recessed housing, unless otherwise noted.
2. Verify luminaire weights and provide backing in wall as required. Luminaires must not droop or tilt away from wall.
3. Wet locations: install sealant between luminaire and outlet box.
4. In circulation areas, wall-mounted luminaires must not project more than 100 mm (4") from wall if mounted above 685 mm (27") and below 2030 mm (80").

3.3 LIGHTING CONTROLS

A. Install controls so that all operable parts are at 48 inches (1220 mm) maximum height.

B. Lighting controls to include occupancy sensors in most spaces (for local control) and relay system lighting control for larger common spaces as indicated on the drawings.

C. Occupancy sensors shall initially be set as follows:
1. Maximum sensitivity.
2. Maximum time delay (or 30 minutes).
3. Manual-on operation.
4. Automatic off operation.
5. Aim all adjustable sensors to properly cover room areas.

D. Timeclock System shall initially be set to control the low voltage relays as per the Relay Panel Schedule LCP.
1. Assign all interior relays to an automatic off sweep, with flick warn (except those noted as "NL"). Off time shall be set to an Owner-determined time in the evening, after dark or normal business operations.
2. Off signals to may originate from BAS system, which shall be inter-connected to the Lighting Control System where indicated on the drawings.
3. Assign all interior relays noted as "NL" to be on 24 hours per day. No automatic relay operation.
4. Assign "after hours" and "Weekend / Holiday" hours to match normal business calendar and times.
5. All interior relays shall be allowed to be overridden by use of the local dataline switches for a maximum of 2 hours (per Title 24) when used after hours or on Weekends / Holidays. If used during these times, automatic shut-off shall re-activate at the end of the 2-hour period.
6. All interior relays shall be allowed to be overridden by use of the local dataline switches when used during normal business hours. Standard timeclock operation shall resume with the next scheduled timeclock function for each relay.
7. Assign all exterior relays for automatic on operation with the astro-dial feature, set to 30 minutes before sunset. Latitude = 37.5 degrees North / Longitude = 122 degrees West.
8. Assign exterior relays noted as "astro-on, astro-off" for automatic off operation with the astro-dial feature, set to 30 minutes after sunrise. Latitude and Longitude as noted above.
9. Assign exterior relays noted as "astro-on, timeclock-off" for automatic off operation with the normal timeclock feature, set to an owner determined time in the late evening.

10. Assign exterior relays noted as "NL" or "On All Night" for astro-dial operation, for automatic on 30 minutes before sunset and automatic off 30 minutes after sunrise.

3.4 DELIVERY, STORAGE, & HANDLING:

A. Deliver luminaires in factory-fabricated containers or wrappings, which properly protect luminaires from damage. Inspect luminaires immediately upon delivery to ensure correct shipment without damage.

B. Store luminaires in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, laid flat and blocked off ground.

C. Handle luminaires carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new. Protection wrapping on louvered (parabolic) luminaires shall not be removed until luminaires are ready for operation.

3.5 SEQUENCING AND SCHEDULING:

A. General:
1. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of luminaires with other work.
2. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

3.6 PROJECT CLOSEOUT

A. Clean luminaires and remove plaster and paint spatters.

B. Clean fingerprints and dust from downlight reflectors. Refer to manufacturer’s instructions.

C. Verify that luminaires and controls are working at time of final acceptance by Owner.
1. Repair or replace lighting control devices that are inoperable.
2. Repair or replace LED modules or entire LED luminaires that are inoperable.
3. Repairs and/or replacements shall be at no additional cost to the Owner.

D. Test emergency lighting system for 90 minutes in presence of Owner's representative, check each luminaire for proper operation at end of 90-minute test, then recharge for 24 hours and briefly test each luminaire again for proper operation.

E. Install and aim adjustable lighting as directed by Architect.
1. Provide personnel, lifts, ladders, and walkie-talkies as required.
2. Aiming will occur at night, outside of normal working hours, at times as approved by the Architect.

F. Prepare two copies of a Lighting Systems Maintenance Manual consisting of the following in a hardcover binder. Deliver to Architect. After review, Architect will deliver one copy to Owner.
1. One complete set of approved submittals, including product data and shop drawings.
2. Luminaire cleaning instructions, including chemicals to be used or avoided.
3. Instructions for code-required testing and maintenance of emergency lighting system.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 265601
SITE LIGHTING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Luminaires

B. LEDs

C. Power Supplies/Drivers

D. Poles

E. Pole bases

F. Controls and wiring

1.2 SYSTEM DESCRIPTION

A. Furnish all labor, materials, apparatus, tools, equipment transportation, temporary construction and special or occasional services as indicated on the Drawings or described in these Specifications and as required to make a complete working site lighting system.

B. Illumination levels shall be in accordance with recommendations by the Illuminating Engineering Society (IES).

1.3 INCORPORATED DOCUMENTS

A. Section 260500 and Section 265101 apply to all work in this Section.

1.4 SUBMITTALS

A. Catalog Information:
   1. Luminaire (each type) with photometric pattern.
   2. Contactors.
   3. Power Supply or Driver (each type)
   4. Poles.
   5. Brackets.

B. Shop Drawings.

C. Manufacturer's Recommendations: Provide two copies before material is used.
   1. PVC conduit joints and junctions.
   2. Solvent welding directions.
   3. Pole bases.

D. Laboratory Test: Determine soil density relationships for compaction of backfill material in accordance with ASTM D1557, Method D.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT

A. Provide new materials and equipment unless otherwise specifically indicated or specified. Materials shall be listed by Underwriter's laboratories, Inc. (U.L.) and bear evidence of such approval where applicable.

B. Luminaires: Site luminaires shall be weatherproof. Reflectors and refractors shall provide the light configuration indicated and conforming to IES recommendations.

C. Luminaires and poles shall be finished in epoxy enamel designed to withstand the effects of salt spray. Lens shall be securely attached to the lens frame for security during maintenance and relamping.

D. Lighting Contactors: NEMA ICS 2. Electrically operated, magnetically held unit in NEMA enclosure, rated poles and ratings as indicated on Drawings. Units shall have silver alloy double breaker contacts and coil clearing contacts and shall require no arcing contacts. On-off selector switch.

E. Poles, Brackets, Pole Bases and Attachments: Shall be rated for service with wind velocities of 100 mph considering the force exerted by the wind on the maximum exposure of the fixture luminaire selected.

F. Poles shall be anchor base type round, height and style as indicated, finished to match luminaire, complete with handhole and gasketed cover, anchor bolts with leveling and locking screws, grounding connection, and matching base cover.

G. Concrete pole bases shall be cast-in-place reinforced concrete as indicated with anchor bolts and conduit entries as per manufacturer. Concrete shall be rated 3,000 PSI at 28 day test.

H. Concrete:
   1. Concrete for electrical requirements shall be at least 3,000 psi concrete with 1-inch maximum aggregate conforming to the requirements of Division 3 for Cast-In-Place concrete.

2.2 SOLID STATE LUMINAIRES

A. Housing, where applicable:
   1. Steel bonderized or equal rust protected, or aluminum, rigid construction. Minimum gauge thickness shall be as follows:
      a. Interior locations: No. 20-gauge steel, No. 16-gauge aluminum.

B. Finish:
   1. Baked enamel finish (except when otherwise specified).
      a. Concealed interior surfaces (this applies to interior hardware, circuit boards, etc.) matte black.
      b. Concealed exterior surfaces: matte black.
      c. Visible surfaces: color and texture as specified below for each luminaire type or as selected.
      d. Exterior luminaire finish: refer to Luminaire Schedule.

C. Light Emitting Diode (LED) requirements:
   1. Correlated color temperature (CCT) for phosphor-coated white LEDs must have the following designated CCT and fall within the following binning standard:

a. 3000K defined as 3045 +/- 175K

2. Color spatial uniformity shall be limited to variations in chromaticity for different directions (i.e. changes in viewing angle) within 0.004 from the weighted average point on the CIE 1976 (u',v') diagram.
3. Color maintenance shall be limited to a maximum change in chromaticity of 0.007 on the CIE 1976 (u',v') diagram over the lifetime of the product.
   a. Color rendering index: Color rendering index to be determined using ANSI C78.377-2008 and applicable IESNA standards.
   b. Laboratory tests must be produced using specific module(s)/array(s) and power supply combination that will be used in production.
   c. Manufacturers must provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories
4. Lumen depreciation
   a. Lumen depreciation to be measured using IESNA LM-80-08 standard for IES approved method of measuring lumen maintenance of LED light sources.
   b. Phosphor coated white LED module(s)/array(s) shall deliver at least 70% of initial lumens for a minimum of 35,000 hours when installed in-situ and operated at 100% output and the maximum specified operating temperature.
   c. Colored LED module(s)/array(s) shall deliver at least 50% of initial lumens for a minimum of 35,000 hours when installed in-situ and operated at 100% output and the maximum specified operating temperature.
5. Acceptable LED manufacturers:
   a. Cree
   b. Nichia
   c. Osram Opto Semiconductors
   d. Philips Lumileds
   e. Soraa
   f. Xicato

D. Luminaire Efficacy:
1. Luminaire efficiency shall be measured using IESNA LM-79-08 standard for electrical and photometric measurements of solid state lighting products.
2. Manufacturer shall provide published luminaire efficacy, which is defined as luminaire light output divided by luminaire input power measured in a 25 degree Celsius environment. Efficacy shall include power supply, thermal, optical, and luminaire losses.

E. Thermal Management:
1. Solid state luminaire shall not exceed LED manufacturer's maximum junction temperature requirements when operated in-situ at luminaire manufacturer's maximum ambient operating temperature and 100% light output.
2. Solid state luminaires shall be thermally protected using one of more of the following thermal management techniques:
   a. Metal core board
   b. Gap pad
   c. Internal monitoring firmware
3. Solid state luminaire housing shall be designed to transfer heat from the LED board to the outside environment.

F. Power Supply/Driver requirements:
1. Power factor of 0.90 or greater for primary application
2. Input current shall have Total Harmonic Distortion (THD) of less than 20%.
3. Minimum operating temperature of minus 20 degrees Celsius or below when used in luminaires intended for outdoor applications.
4. Output operating frequency to be equal to or greater than 120 Hz.

5. Operate with sustained input variations of +/- 10% (voltage and frequency) with no damage to the driver.
6. Tolerate sustained open circuit and short circuit output conditions without damage and without need for external fuses or trip devices.
7. Output shall be regulated to +/- 5% across published load range.
8. Class A sound rating.
9. Outputs shall have current limiting protection.
10. Operate LEDs at constant and regulated current levels. LEDs shall not be overdriven beyond the diode manufacturer's specified nominal voltage and current.
11. Inrush currents not exceeding peak currents in NEMA 410.

G. Solid State Lighting Controls:
1. Control interface to dimmable power supplies shall consist of one of the following:
a. Line Voltage Dimming. Controls to be rated for magnetic or electronic low voltage transformer operation.
b. Low voltage (0-10V) control. Controls to be compatible with either current sink or current source operation.
c. DMX control
2. Dimmable LED power supplies shall use pulse width modulation (PWM) to regulate power to LEDs
a. Dimmable power supplies shall have 12-bit or greater resolution to obtain flicker-free operation throughout the dimming range.

H. System Installation
1. Hardwired connections to solid state luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
2. All solid state luminaires (100% of each lot) shall undergo a minimum eight-hour burn-in test during manufacturing. Solid state lighting installations shall be UL Listed as a low-voltage lighting system including, but not limited to, luminaire, power supply, controller, keypad, and wiring.

I. Warranty
1. Luminaires, drivers, and controllers for solid state lighting systems shall be covered by a minimum five-year warranty against defects in workmanship or material. Warranty shall include in-warranty service program providing for payment of authorized labor charges incurred in replacement of inoperative in-warranty equipment.

2.3 LUMINAIRE CONSTRUCTION

A. Sheet metal: materials and thicknesses shall be 20 gauge (0.7 mm or 0.027") min., free of dents, scratches, oil-can, or other defects.

B. Painted luminaires: exposed weld marks, joints, and seams shall be filled and sanded smooth before finishing.

C. All edges cleaned and dressed to remove sharp edges or burrs.

D. Extrusions: 1/10" min. wall thickness, smooth and free of tooling lines, with cast end plates that exactly match extrusion profiles.

E. Castings: smooth, free of pits, scales, gate marks, or blemishes.

F. Spinnings shall have 1/32" min. thickness, smooth, free of spinning lines or blow-back, with clean edges.

G. Welds: Follow recommendations of American Welding Society. All welds continuous and free of spatter, residue, or warping.

H. No light leaks visible. Field paint exterior of housing with high temperature paint if necessary.

I. Exposed end plates and joiners, with concealed fasteners.

J. Hardware:
   1. Steel or aluminum exterior luminaires: stainless steel hardware.
   2. Stainless steel luminaires: stainless steel hardware.
   3. Copper alloy luminaires: brass hardware.

K. Raceways: Where used for through wiring, luminaires must be approved for use as raceways.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Refer to Section 262700, Part 2.2, for wiring and splicing requirements.

B. Underground cable installation shall conform to National Electrical Code except as otherwise specified or indicated.

C. Contractor Damage: The Contractor shall promptly cause repairs to be made to any indicated utility lines or systems damaged by his operation.

D. Under roads and paved areas, ducts shall be EPC-80-PVC polyvinyl chloride conduit.

E. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

F. Bends in cables shall have an inner radius of not less than 12 times the cable diameter.

G. Horizontal slack of approximately 3 feet shall be left in the ground on each end of cable runs, on each side of connection and at all points where connections are to be made above ground level.

H. Earthwork: Earthwork for electrical requirements shall conform to the requirements of Division 31.

I. Coordinate work with other trades. Pre-ship anchor bolts and templates for use in preparing bases for installation. After leveling luminaires, pack grout between mounting plate and concrete footing. Provide weep holes to prevent accumulation of moisture inside pole base.

3.2 TESTS

A. Test under provisions of Division 1, Section 260800, and Section 265101.

B. The Owner shall be notified at least three working days in advance of the Contractor's proposed date of the tests to permit scheduling, and to permit witnessing of the tests. The Contractor shall furnish the Owner with three copies of the results of the tests.

C. Circuits: The Contractor shall test each circuit, all controllers, and components of the system for proper operation. The Contractor shall furnish the Owner with three copies of the test results.

D. Compaction Tests: Backfill shall be tested for compaction in accordance with ASTM D1556.

E. Operating Test: Contractor shall operate the system in the presence of the Owner proving the proper operation.

END OF SECTION

SECTION 265700

LOW VOLTAGE LIGHTING CONTROL SYSTEM

(NETWORK, DEMAND RESPONSE, BMS INTEGRATION)

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Furnish all labor, materials, apparatus, tools, equipment transportation, temporary construction and commissioning services as indicated on the Drawings or described in these Specifications and as required to make a complete working facility lighting control system.

B. Integrated Low Voltage Lighting Control System:
   1. The low voltage lighting control system shall consist of relay panels, digital device Segment Manager and LMCS system configuration software.
   2. The system shall accept program changes from the LMCS system configuration software for date and time, location, holidays, event scheduling, button binding and group programming.

C. Requirements are indicated in Section 262700 for raceways and electrical boxes and fittings required for installation of control equipment and wiring.

D. Provide CBC 2016 compliant seismic installation. See Section 260500 for all certification and submittal requirements.

1.2 INCORPORATED DOCUMENTS

A. Sections 260500, 262700, 265101 and 265601 apply to all Work in this Section.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer Qualifications: Installer shall be one who is experienced in performing the Work of this Section, and who has specialized in installation of Work similar to that required for this project.

C. Component Pre-testing: All components and assemblies are to be factory pre-tested prior to installation.

D. System Support: Factory applications engineers shall be available for telephone support.

E. NEC Compliance: Comply with NEC as applicable to electrical wiring Work.

F. NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

G. UL Approvals: Remote panels are to be UL listed under UL 916 Energy Management Equipment.

H. CSA Approvals: Remote panels are to be CSA listed.

I. FCC Emissions: All assemblies are to be in compliance with FCC emissions Standards specified in Part 15 Subpart J for Class A application.

J. All System components shall be California Title 24 compliant, where applicable.

1.4 SUBMITTALS

A. Submit under provisions of Division 1 and 260500.
   1. Bill of Materials: Complete list of all parts needed to fully install selected System components.
   2. Shop Drawings: Submit dimensional Drawings of all lighting control system components and accessories.
   3. One Line Diagram: Submit a one-line diagram of the system configuration.
   4. Typical Wiring Diagrams: Submit typical wiring diagrams for all components including, but not limited to, relay panels, relays, digital low voltage switches, digital occupancy sensors and digital daylighting controls.

1.5 MANUFACTURERS

A. Integrated Low Voltage Lighting Control System:
   1. The basis of the specified system is the Watt Stopper Digital Lighting Management (DLM) or an equal. Any other system to be considered must submit descriptive information 10 days prior to bid.

B. Prior approval does not guarantee final approval by the electrical engineer. The contractor shall be completely responsible for providing a system meeting this specification in its entirety. All deviations from this specification must be listed and individually signed off by the engineer.

C. The Owner reserves the right to reject a proposed substitution based on his agent's professional judgment as to the utility, visual appropriateness, or finish of substitutions.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials in Manufacturer's original, unopened, undamaged packages with intact identification labels.

B. Storage and Protection: Store materials away from exposure to harmful weather conditions and at temperature and humidity conditions recommended by Manufacturer.

1.7 GUARANTEE AND WARRANTIES

A. All Work performed under this Section must be guaranteed to be free of defects in products or workmanship for one year after date of acceptance by Owner, unless noted otherwise in General Conditions.

PART 2 – PRODUCTS

2.1 DIGITAL LIGHTING MANAGEMENT DLM

A. Description
   1. Lighting Control System shall include Dimming / Switching Room Controllers, Digital Occupancy Sensors, Digital Daylight Sensors, Digital Dimmers / Switches, Network

Components and Relay Panels. All project components shall be UL listed and consist of the following:

2. Lighting Control Panel Enclosure Tub: NEMA 1, NEMA 3R, or NEMA 4 as indicated on the drawings, sized to accept an interior with 1-8 relays, 1-24 relays and six (6) four pole contactors, or 1-48 relays with six (6) four pole contactors.
3. Cover: Surface or Flush as required, hinged and lockable and with restricted access to line voltage section. A final typed wiring schedule directory card shall be affixed to the cover's back.
4. Interior: Barrier included for separation of high voltage (class 1) and low voltage (class 2) wiring. The interior shall include intelligence boards, power supply, mechanically latched control relays and multi-pole contactors. The interiors shall include the following features:
    a. Screwless, removable, plug-in connections for all low voltage terminations.
    b. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches, digital occupancy sensors and digital daylight sensors.
    c. Each relay shall be capable of individual ON/OFF control by a low voltage switch and / or occupancy sensor input.
    d. The system shall monitor true relay status; the relay status shall be displayed at the onboard pilot LED and monitored by the system electronics.
    e. Stagger the On and OFF sequence of the relays.
    f. Heavy Duty Relays – Mechanically latching contacts with single moving part design for improved reliability. Relays to have the following characteristics:
        1) 30 amp NEMA 410 electronic ballast rated and 20 amp tungsten, rated for 50,000 ON/OFF cycles at full load. Support #12-#14 AWG solid or stranded wire and rated for 120 and 277 volts; 20 amp NEMA 410 electronic ballast rated and 20 amp tungsten 347 volts.
            (a) 30 VAC isolated contacts for status feedback and pilot light indication.
            (b) 14,000 amp short circuit current rating.
            (c) Contactors shall be DIN rail mounted, four pole standard, normally open or normally closed, electrically held with 120 or 277 volt coil voltage to match panel control power voltage. Contractors shall be compatible with all lighting, ballast and HID loads and be rated for 277 volt 20 amp tungsten and 600 volt 30 amp ballast loads.
5. Power Supply: Multi-voltage transformer assembly with enough power to supply all electronics, occupancy sensors, dataline switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.
6. Multiple panels shall be able to be networked together for global control. The LMCP panels shall be networked together over a MS/TP 3-conductor connection.

2.2 GROUP, CHANNEL, SCHEDULE AND PATTERN CONTROL

A. Description
1. The lighting control panel shall support schedule, group, and photocell control functions via the network as configured using the LMCS Configuration Software.
2. Group Status: Each group pushbutton shall include an LED status indication. The LED shall be ON whenever all of the relays within the group are ON; and shall go OFF when all of the relays within the group go OFF. The LED will be green when in a "mixed" state. Each channel shall also have an associated dry contact closure and pilot contact which tracks the LED operation described above.

B. Features
1. Individual relays shall be able to be assigned to more than one channel, and the channel status shall be annunciated appropriately.

2. Each channel shall also have an input for connecting switch or dry contacts for controlling a channel. Inputs shall accept 2 or 3-wire maintained or momentary inputs, and groups shall be controllable by: an on-board group pushbutton switch, low voltage switch, digital switch, digital occupancy sensor, digital photocell, or time of day.
3. Screwless, removable, plug-in terminals will be provided for all low voltage wiring connections.

2.3 NETWORK CLOCK

A. Description
1. Provide an eight channel integral network clock that connects to the system using the digital MS/TP three conductor data communications wire network described in Section 2.10.
2. The clock shall be used to schedule any of the eight global channel groups (Section 2.03) in the relay panel network. The clock shall support all of the energy saving features required of ASHRAE 90.1 – 2001, IECC 2003, as well as all state and local energy codes.
3. The clock shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and shall include a battery back-up for the clock function and EEPROM for program retention. Clocks that require multiple events to meet local Code lighting shut off requirements shall not be allowed.
4. The clock shall allow unique scenario and time delays. Scenarios shall include:
   a. Scheduled ON / OFF
   b. Manual ON / Scheduled OFF
   c. Manual ON / Auto Sweep OFF (for AS-100 Switches)
   d. Astro ON / OFF (or Photo ON / OFF)
   e. Astro and Schedule ON / OFF (for Photo and Schedule ON / OFF)

B. Features
1. Runs event-based schedule routines independently (does not require BAS or Segment Manager).
2. Supports astronomical, time-based event types
3. Retains memory and time for a minimum of 10 years.

2.4 DIGITAL SWITCHES

A. Description
1. Intelligent digital switching shall operate on the DLM Category 5e local network. Switches shall be available in single, dual, quad, or octal (1-button, 2-button, 4-button, or 8-button) designs. All devices shall mount in a standard single-gang box
2. Each button in a switch shall be able to be individually programmed. Programming shall be done by the LMCT-100 handheld configuration tool. Each button shall control any one of the following options:
   a. Any individual relay in any single panel.
   b. Any group of relays in any single panel.
   c. Any group of relays in the system.

B. Features
1. Switches shall be constructed of non-breakable Lexan on all exposed parts and shall include a matching screwless Lexan wall plate.
2. Individual buttons shall be custom engraved with a maximum of 15 characters (including spaces) on two lines, where shown on plans.
3. Multiple digital switches wired to control the same relay or relay group shall indicate the same status automatically.

4. Each switch shall also include a locator light illuminating the switch for easy location in the dark.
5. Switches can be configured to follow a “Cleaning” scenario. This specific scenario shall prevent the cleaners from overriding OFF any relays turned ON by the occupant.

2.5 DIGITAL OCCUPANCY SENSORS

A. Description
1. Digital Occupancy Sensors – Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.

2.6 DIGITAL PHOTOSENSORS

A. Description
1. Digital Photosensors – Single-zone closed loop, multi-zone open loop and dual-loop daylighting sensors with two-way active infrared (IR) communications shall provide switching, bi-level, tri-level or dimming control for daylight harvesting.

2.7 DIGITAL DIMMING / SWITCHING ROOM CONTROLLERS

A. Description
1. Digital controllers for lighting and plug loads shall automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room and plug load controllers shall be provided to match the room lighting and plug load control requirements. The controllers shall be simple to install, and shall not have dip switches or potentiometers, or require special configuration for standard Plug n’ Go applications. The control units shall include the following features.
2. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
3. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.
4. Multiple room controllers connected together in a local network must automatically prioritize each room controller, without requiring any configuration or setup, so that loads are sequentially assigned using room controller device ID’s from highest to lowest.
5. Device Status LEDs to indicate:
   a. Data transmission
   b. Device has power
   c. Status for each load
   d. Configuration status
6. Quick installation features including:
   a. Standard junction box mounting
   b. Quick low voltage connections using standard RJ-45 patch cable
7. Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:
   a. Turn on to 100%
   b. Remain off
   c. Turn on to last level
8. Each load shall be configurable to operate in the following sequences based on occupancy:
   a. Auto-on/Auto-off (Follow on and off)
   b. Manual-on/Auto-off (Follow off only)
9. The polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.
10. BACnet object information shall be available for the following objects:

a. Load status
b. Electrical current
c. Total watts per controller
d. Schedule state – normal or after-hours
e. Demand response control and cap level
f. Room occupancy status
g. Total room lighting and plug loads watts
h. Total room watts/sq ft
i. Force on/off all loads

11. UL 2043 plenum rated
12. Manual override and LED indication for each load
13. Dual voltage (120/277 VAC, 60 Hz). 120/277 volt models rated for 20A total load, derating to 16A required for some dimmed loads (forward phase dimming); plug load controllers shall carry application-specific UL 20 rating for receptacle control.
14. Zero cross circuitry for each load
15. All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.

B. On/Off Room Controllers shall include:
1. One or two relay configuration
2. Efficient 150 mA switching power supply
3. Three RJ-45 DLM local network ports with integral strain relief and dust cover
4. WattStopper product numbers: LMRC-101, LMRC-102

C. On/Off/Dimming enhanced Room Controllers shall include:
1. Real time current monitoring
2. Multiple relay configurations
   a. One, two or three relays (LMRC-21x series)
   b. One or two relays (LMRC-22x series)
3. Efficient 250 mA switching power supply
4. Four RJ-45 DLM local network ports with integral strain relief and dust cover
5. One dimming output per relay
   a. 0-10V Dimming - Where indicated, one 0-10 volt analog output per relay for control of compatible ballasts and LED drivers. The 0-10 volt output shall automatically open upon loss of power to the Room Controller to assure full light output from the controlled lighting. (LMRC-21x series)
   b. Line Voltage, Forward Phase Dimming - Where indicated, one forward phase control line voltage dimming output per relay for control of compatible two-wire or three-wire ballasts, LED drivers, MLV, forward phase compatible ELV, neon/cold cathode and incandescent loads. (LMRC-22x series)
   c. Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected ballast or driver.
   d. The LED level indicators on bound dimming switches shall utilize this new maximum and minimum trim.
   e. Each dimming output channel shall have an independently configurable minimum and maximum trim level to set the dynamic range of the output within the new 0-100% dimming range defined by the minimum and maximum calibration trim.
   f. Calibration and trim levels must be set per output channel.
   g. Devices that set calibration or trim levels per controller are not acceptable.
   h. All configuration shall be digital. Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.

6. Each load shall have an independently configurable preset on level for Normal Hours and After Hours events to allow different dimmed levels to be established at the start of both Normal Hours and After Hours events.
7. Fade rates for dimming loads shall be specific to bound switch buttons, and the load shall maintain a default value for any bound buttons that do not specify a unique value.
8. The following dimming attributes may be changed or selected using a wireless configuration tool:
    a. Establish preset level for each load from 0-100%
    b. Set high and low trim for each load
    c. Set lamp burn in time for each load up to 100 hours
9. Override button for each load shall provide the following functions:
    a. Press and release for on/off control
    b. Press and hold for dimming control
10. WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMRC-221, LMRC-222

D. Plug Load Room Controllers shall include:
1. One relay configuration with additional connection for unswitched load
2. Configurable additive time delay to extend plug load time delay beyond occupancy sensor time delay (e.g. a 10 minute additive delay in a space with a 20 minute occupancy sensor delay shall ensure that plug loads turn off 30 minutes after the space is vacated).
3. Factory default operation shall be Auto-on/Auto-off, based on occupancy
4. Real time current monitoring of both switched and un-switched load (LMPL-201 only)
5. Efficient switching power supply
    a. 150mA (LMPL-101)
    b. 250mA (LMPL-201)
6. RJ-45 DLM local network ports
    a. Three RJ-45 ports (LMPL-101)
    b. Four RJ-45 ports (LMPL-201)
7. WattStopper product numbers: LMPL-101, LMPL-201.

2.8 DLM SEGMENT NETWORK (ROOM TO ROOM NETWORK).

A. The segment network shall be a linear topology, BACnet-based MS/TP subnet to connect DLM local networks (rooms) and LMCP relay panels for centralized control.
1. Each connected DLM local network shall include a single network bridge (LMBC-300), and the network bridge shall be the only room-based device that is connected to the segment network.
2. Network bridges, relay panels and segment managers shall include terminal blocks, with provisions for separate “in” and “out” terminations, for segment network connections.
3. The segment network shall utilize twisted pair, shielded, cable as specified by the lighting control manufacturer. The maximum cable run for each segment shall be 4,000 feet. Conductor-to-conductor capacitance of the twisted pair shall be less than 30 pf/ft and have a characteristic impedance of 120 Ohms.
4. Network signal integrity will require that each conductor and ground wire be correctly terminated at every connected device.
5. Substitution of manufacturer-specified cable must be pre-approved: Manufacturer may not certify network reliability and may void warranty, if non-approved cable is installed, and if terminations are not completed according to manufacturer’s specific requirements.
6. Segment networks shall be capable of connecting to BACnet-compliant BAS (provided by others) either directly, via MS/TP, or through NB-ROUTERs, via BACnet/IP or BACnet/Ethernet. Systems whose room-connected network infrastructure require gateway devices to provide BACnet data to a BAS are unacceptable.

B. WattStopper Product Number: LM-MSTP, LM-MSTP-DB

2.9 CONFIGURATION TOOLS

A. A wireless configuration tool shall facilitate optional customization of DLM local networks using two-way infrared communications, while PC software shall connect to each local network via a USB interface.

B. Features and functionality of the wireless configuration tool shall include but not be limited to:
   1. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
   2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
   3. Ability to to read and modify parameters for room controllers, occupancy sensors, wall switches, daylighting sensors, network bridges and relay panels, and identify room devices by type and serial number.
   4. Ability to save up to eight occupancy sensor setting profiles, and apply profiles to selected sensors.
   5. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
   6. Adjust or fine-tune daylighting settings established during auto-configuration, and input light level data to complete configuration of open loop daylighting controls.
   7. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
   8. Verify status of building level network devices.

C. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100

2.10 NETWORK BRIDGE

A. The network bridge module shall connect a DLM local network to a BACnet-compliant segment network for communication between rooms, relay panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication and an optically isolated EIA/TIA RS-485 transceiver.
   1. The network bridge shall be provided as a separate module connected on the local network through an available RJ-45 port.
   2. Provide Plug n' Go operation to automatically discover room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
   3. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. BACnet objects shall be created for the addition or replacement of any given in-room DLM device for the installed life of the system. Products requiring that an application-specific point database be loaded to create or map BACnet objects are not acceptable. Systems not capable of providing BACnet data for control devices via a dedicated BACnet Device ID and physical MS/TP termination per room are not acceptable. Standard BACnet objects shall be provided as follows:
      a. Read/write the normal or after hours schedule state for the room
      b. Read the detection state of each occupancy sensor
      c. Read the aggregate occupancy state of the room
      d. Read/write the On/Off state of loads
      e. Read/write the dimmed light level of loads

f. Read the button states of switches
g. Read total current in amps, and total power in watts through the room controller
h. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
i. Activate a preset scene for the room
j. Read/write daylight sensor fade time and day and night setpoints
k. Read the current light level, in foot-candles, from interior and exterior photosensors and photocells
l. Set daylight sensor operating mode
m. Read/write wall switch lock status
n. Read watts per square foot for the entire controlled room
o. Write maximum light level per load for demand response mode
p. Read/write activation of demand response mode for the room
q. Activate/restore demand response mode for the room

B. WattStopper product numbers: LMBC-300

2.11 SEGMENT MANAGER

A. For networked applications, the Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser utilizing either unencrypted TCP/IP traffic via a configurable port (default 80) or 256 bit AES encrypted SSL TCP/IP traffic via a configurable port (default 443).

B. Each segment manager shall have integral support for at least three segment networks. Segment networks may alternately be connected to the segment manager via external routers and switches, using standard Ethernet structured wiring. Each router shall accommodate one segment network. Provide the quantity of routers and switches as shown on the plans.

C. Operational features of the Segment Manager shall include the following:
1. Connection to PC or LAN via standard Ethernet TCP/IP with the option to use SSL encrypted connections for all traffic.
2. Easy to learn and use graphical user interface, compatible with latest version of Internet Explorer, or equal browser. Shall not require installation of any lighting control software to an end-user PC.
3. Log in security capable of restricting some users to view-only or other limited operations.
4. Automatic discovery of DLM devices and relay panels on the segment network(s). Commissioning beyond activation of the discovery function shall not be required to provide communication, monitoring or control of all local networks and lighting control panels.
5. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree shall allow the device settings and operational parameters to be viewed and changed by the user.
6. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation including sensor time delays and sensitivities, and load response to sensor including Manual-On or Auto-On.
7. Ability to set up schedules for rooms and panels, view and override current status of panel channels and relays, and assign relays to groups. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation. Support for a minimum of 100 unique schedules, each with up to four time events per day. Support for annual schedules, holiday schedules and unique date-bound schedules.
8. Ability to group rooms and loads for common control by schedules, switches or network commands.

9. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.
10. Provide capabilities for integration with a BAS via BACnet protocol. At a minimum, the following points shall be available to the BAS via BACnet IP connection to the segment manager: room occupancy state; room schedule mode; room switch lock control; individual occupancy sensor state; room lighting power; room plug-load power; load ON/OFF state; load dimming level; panel channel schedule state; panel relay state; and Segment Manager Group schedule state control.
11. The Segment Manager shall allow access and control of the overall system database via Native Niagara AX FOX connectivity. Systems that must utilize a Tridium Niagara controller in addition to the programming, scheduling and configuration server are not acceptable.

D. Segment Manager shall support multiple DLM rooms as follows:
1. Support up to 120 network bridges and 900 digital in-room devices (LMSM-3E).
2. Support up to 300 network bridges and 2,200 digital in room devices, connected via network routers and switches (LMSM-6E).

E. WattStopper Product Numbers: LMSM-3E, LMSM-6E, NB-ROUTER, NB-SWITCH, NB-SWITCH-8, NB-SWITCH-16.

2.12 PROGRAMMING, CONFIGURATION AND DOCUMENTATION SOFTWARE

A. PC-native application for optional programming of detailed technician-level parameter information for all DLM products, including all parameters not accessible via BACnet and the handled IR configuration tool. Software must be capable of accessing room-level parameter information locally within the room when connected via the optional LMCI-100 USB programming adapter, or globally for many segment networks simultaneously utilizing standard BACnet/IP communication.

B. Additional parameters exposed through this method shall include but not be limited to:
1. Occupancy sensor detection LED disable for performance and other aesthetic spaces where blinking LEDs present a distraction.
2. Six occupancy sensor action behaviors for each controlled load, separately configurable for normal hours and after hours modes. Modes include: No Action, Follow Off Only, Follow On Only, Follow On and Off, Follow On Only with Override Time Delay, Follow Off Only with Blink Warn Grace Time, Follow On and Off with Blink Warn Grace Time.
3. Separate fade time adjustments per load for both normal and after hours from 0 - 4 hours.
4. Configurable occupancy sensor re-trigger grace period from 0 - 4 minutes separate for both normal hours and after hours.
5. Separate normal hours and after hours per-load button mode with modes including: Do nothing, on only, off only, on and off.
6. Load control polarity reversal so that on events turn loads off and vice versa.
7. Per-load DR (demand response) shed level in units of percent.
8. Load output pulse mode in increments of 1 second.
9. Fade trip point for each load for normal hours and after hours that establishes the dimmer command level at which a switched load closes its relay to allow for staggered On of switched loads in response to a dimmer.

C. Generation of reports at the whole file, partial file, or room level. Reports shall include but not be limited to:
1. Device list report: All devices in a project listed by type.
2. Load binding report: All load controller bindings showing interaction with sensors, switches, and daylighting.

3. BACnet points report: Per room Device ID report of the valid BACnet points for a given site's BOM.
4. Room summary report: Device manifest for each room, aggregated by common BOM, showing basic sequence of operations.
5. Device parameter report: Per-room lists of all configured parameters accessible via hand held IR programmer for use with O&M documentation.
6. Scene report: All project scene pattern values not left at defaults (i.e. 1 = all loads 100%, 2 = all loads 75%, 3 = all loads 50%, 4 = all loads 25%, 5-16 = same as scene 1).
7. Occupancy sensor report: Basic settings including time delay and sensitivity(ies) for all occupancy sensors.

D. Network-wide programming of parameter data in a spreadsheet-like programming environment including but not limited to the following operations:
1. Set, copy/paste an entire project site of sensor time delays.
2. Set, copy/paste an entire project site of sensor sensitivity settings.
3. Search based on room name and text labels.
4. Filter by product type (i.e. LMRC-212) to allow parameter set by product.
5. Filter by parameter value to search for product with specific configurations.

E. Network-wide firmware upgrading remotely via the BACnet/IP network.
1. Mass firmware update of entire rooms.
2. Mass firmware update of specifically selected rooms or areas.
3. Mass firmware upgrade of specific products.

F. WattStopper Product Number: LMCS-100, LMCI-100

PART 3 - EXECUTION

3.1 INSTALLATION

A. Integrated Low Voltage Lighting Control System:
1. Digital Switches and/or photocells shall be mounted in the spaces as indicated on the Drawings. Each low voltage wire shall be labeled clearly indicating which relay panel it connects to. Use only Watt Stopper pre-terminated LMRJ series Cat 5e cable as indicated on the Drawings. All relays and switches shall be tested after installation to confirm proper operation and the loads recorded on the directory card in each panel.
2. The relay panels shall be mounted in electrical closets as indicated on the Drawings. The numbered relays in the panel shall be wired to control the power to each load as indicated on the Panel Wiring Schedules included in the Drawings. All power wiring shall be identified with the circuit breaker number controlling the load. If multiple circuit breaker panels are feeding into a relay panel, wires shall clearly indicate the originating panel's designation.

3.2 PRE-INSTALLATION MEETING

A. Manufacturer shall provide a factory authorized representative to provide a functional overview of the lighting control system prior to products being installed.
1. Discuss functionality and integration of all products per design requirements.
2. Confirm location of occupancy sensors and photocells as required.
3. Confirm low voltage control wires meet specification.
4. Explain adjustment options and verify specification requirements for each device.

3.3 PROGRAMMING

A. Set / program lighting controls per relay schedules on drawings, with input from Owner for exact times required for each operation.

B. All programming shall comply with Title 24 requirements (i.e. automatic control and override limits).

C. For relays controlling halogen and metal halide lamps, a minimum 15 minute off period is required per day to mitigate potential for non-passive end of life failure. Review programming schedules and program this off-cycle for relays otherwise scheduled for continuous operation. Coordinate timing of off-cycle with Owner.

D. Test all programming for proper operation of each relay at scheduled times.

3.4 SYSTEM STARTUP

A. The Manufacturer shall provide a factory authorized technician to commission and confirm proper installation and operation of all system components.

B. Contractor shall provide system documentation after the equipment has been installed:
   1. Lighting control operational summary sheet.
   2. Programming record sheet.
   3. System Installation and Operation Manual shall be provided to the owner.

3.5 TRAINING

A. Manufacturer shall provide factory authorized application engineer to train Owner personnel in the operation and programming of the lighting control system for the first (2) two days of occupancy; then (1) one week later, and again (1) month later.

3.6 TESTS

A. Test under provisions of Section 260500 and 260800.

B. The Owner shall be notified at least three working days in advance of the Contractor's proposed date of the tests to permit scheduling, and to permit witnessing of the tests. The Contractor shall furnish the Owner with three copies of the results of the tests.

C. Circuits: The Contractor shall test each circuit, all controllers, and components of the system for proper operation. The Contractor shall furnish the Owner with three copies of the test results.

D. Operating Test: Contractor shall operate the system in the presence of the Owner proving the proper operation of the system and all components.

END OF SECTION

CSECTION 27 00 00

BASIC COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general administrative and procedural requirements for Division 27, and is intended to supplement, not supersede, the general requirements specified in Division 00.

B. The requirements described herein include the following:
1. References
2. Definitions
3. System Description and Project Conditions
4. Submittals
5. Quality Assurance
6. Delivery, Storage, and Handling
7. Sequencing
8. Owner's Instructions
9. Scheduling
10. Warranty
11. Start Up
12. Commissioning
13. Maintenance
14. Product Substitutions
15. Project Management and Coordination Services
16. Permits and Inspections
17. Field Quality Control
18. Project Closeout and Record Documents

C. Related Items
1. General and Supplementary Conditions: General provisions of the Prime Contract and Divisions 00 and 01 apply to Division 27.
2. Consult other Divisions and Sections, determine the extent and character of related work, and coordinate Work of Division 27 with that specified elsewhere to produce a complete and operable installation.
3. Section 270526, "Communications Bonding"
4. Section 270528, "Communications Building Pathways"
5. Section 270533, "Communications Building Pathways – Conduits and Boxes"
6. Section 270536, "Communications Building Pathways – Cable Tray"
7. Section 270811, "Communications Twisted Pair Testing"
8. Section 270821, "Communications Optical Fiber Testing"
9. Section 271100, "Communications Equipment Rooms"
10. Section 271313, "Communications Backbone ISP Twisted Pair Cabling"
11. Section 271323, "Communications Backbone ISP Fiber Optic Cabling"
12. Section 271513, "Communications Horizontal Twisted Pair Cabling"
13. Section 274116, "Integrated Audio Video Equipment"

1.2 REFERENCES

A. General
   1. Codes, standards, and industry manuals/guidelines listed by reference, including revisions by issuing authority, form a part of this specification section to extent indicated. Consider such codes and/or standards a part of this specification as though fully repeated herein.
   2. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.
   3. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid unless otherwise specifically stated.

B. Codes: Perform work and furnish materials and equipment under Division 27 in accordance with applicable requirements of the latest edition of governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:
   1. California Code of Regulations (CCR):
      a. Title 8, “Industrial Relations”
         1) Chapter 3.22, “California Occupational Safety and Health Regulations (CAL/OSHA)”
      b. Title 24, “California Building Standards Code”
         1) Part 1, “California Building Standards Administrative Code”
         2) Part 2, “California Building Code” (CBC)
         3) Part 3, “California Electrical Code” (CEC)
         4) Part 11, “California Green Building Standards Code” (CALGeen)”
   2. National Fire Protection Agency (NFPA)
      a. NFPA 75, “Protection of Information Technology Equipment”
   3. Code of Federal Regulations (CFR) Title 47 “Telecommunication”, Chapter I “Federal Communications Commission (FCC)”:
      a. Part 15, “Radio Frequency Devices and Radiation Limits”
      b. Part 27, “Miscellaneous Wireless Communications Services”
      c. Part 68, “Connection of Terminal Equipment to the Telephone Network”
      d. Part 90, “Private Land Mobile Radio Services”
   4. International Code Council (ICC):
      a. “International Building Code” (IBC)
      b. “International Fire Code” (IFC)
      c. “ICC Performance Code”
   5. Other applicable national, state, and local binding building and fire codes

C. Standards: Perform work and furnish materials and equipment under Division 27 in accordance with the latest editions of the following standards as applicable:
   1. Building Industry Consulting Services International (BICSI):
      a. “Telecommunications Distribution Methods Manual” (TDMM)
      b. “Customer-Owned Outside Plant Design Manual”
      c. “Wireless Design Reference Manual” (WDRM)
      d. “Network Design Reference Manual” (NDRM)
   2. EIA testing standards
   3. National Electrical Contractors Association (NECA):
      a. ANSI/NECA 1-2015, “Standard Practices for Good Workmanship in Electrical Construction”

4. Telecommunications Industry Association (TIA):
    a. ANSI/TIA-568.0-D, “Generic Telecommunications Cabling for Customer Premises”
    b. ANSI/TIA-568.1-D, “Commercial Building Telecommunications Cabling Standards”
    c. ANSI/TIA-568.2-C, “Balanced Twisted Pair Telecommunications Cabling and Components”
    d. ANSI/TIA-568.3-D, “Optical Fiber Cabling Components”
    e. ANSI/TIA-569-D, “Telecommunications Pathways and Spaces”
    f. ANSI/TIA/EIA-598-D, “Optical Fiber Cable Color Coding”
    g. ANSI/TIA-606-C, “Administration Standard for Telecommunications Infrastructure”
    h. ANSI-TIA-607-C, “Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises”
    i. ANSI/TIA-758-B, “Customer-Owned Outside Plant Telecommunications Infrastructure Standard”
    j. ANSI/TIA-1005-A, “Telecommunications Infrastructure Standard for Industrial Premises”

1.3 DEFINITIONS

A. The definitions of Divisions 00 and 01 shall apply to Division 27 sections.

B. In addition to those definitions of Divisions 00 and 01, the following list of terms as used in this specification defined as follows:
1. “AFF”: Above Finished Floor
2. “As directed”: As directed or instructed by the Owner, or their authorized representative
3. “AHJ”: Authority Having Jurisdiction
4. “Cabling”: installed media ready for electronic or optical signal circuit use; a complete media connection comprised of cables, termination apparatus (patch panels, blocks, connectors), outlets, connecting media (path cord, crossconnects), labeling
5. “CBC”: California Building Code (CCR Title 24 Part 2)
6. “CCR”: California Code of Regulations
7. “CEC”: California Electrical Code (CCR Title 24 Part 3)
8. “Connect”: To install patch cords, equipment cords, crossconnect wire, etc. to complete an electronic or optical signal circuit
9. “Cord”: a length of cordage having connectors at each end. The term “Cord” is synonymous with the term “Jumper” and “Lead”
10. “Engineer”: TEECOM
11. “First-In-Place”: a single unit of work for the Owner’s and Engineer’s review and written approval prior to proceeding with the work of the entire project
12. “Furnish”: To purchase, procure, acquire, and deliver complete with related accessories
13. “General Contractor”: <name><successful bidder>
14. “Identifier”: A unique code assigned to an element of the Telecommunications infrastructure that links it to its corresponding record
15. “Install”: To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test before turning over to the Owner, parts, items, or equipment supplied by contractor or others. Make installation complete and ready for regular operation
16. “IOR”: Inspector Of Record
17. “ISP”: Inside Plant
18. “LED”: Light Emitting Diode
19. “MSDS”: Material Safety Data Sheets
20. “NEC”: National Electrical Code (NFPA 70)
21. “NEMA”: National Electrical Manufacturers Association
22. “NFPA”: National Fire Protection Agency
23. “NIC”: Not In Contract (work or equipment)

24. “OFCI”: Owner-furnished contractor-installed; coordinate the integration of components furnished by the Owner; provide mounting hardware, cable, connectors, etc. to ensure proper integration of OFCI equipment
25. “OFE”: Owner Furnished Equipment
26. “OSP”: Outside Plant
27. “Owner”: <name>
28. “Owner’s Representative”: <name>
29. “PDF”: portable document format (electronic file format / *.pdf)
30. “Pigtail”: a length of cordage having connectors at one end
31. “Provide”: To furnish, transport, install, erect, connect, test and turn over to the Owner, complete and ready for regular operation
32. “UL”: Underwriters Laboratories

1.4 SYSTEM DESCRIPTION AND PROJECT CONDITIONS

A. In circumstances where the Specifications and Drawings conflict, the Drawings shall govern quantity and the Specifications shall govern quality.

B. Asbestos Abatement
   1. Refer to Division 01 (0135xx Special Procedures) and the Owner’s procedures for asbestos handling.
   2. Abate asbestos prior to the start of work that would disrupt existing asbestos.
   3. The first week of construction, mark locations of penetrations and other areas where known asbestos will be disturbed from construction activities. Coordinate abatement to occur between January 1, 2020 and December 31, 2021.

1.5 SUBMITTALS

A. Submit required submittals to the <General Contractor><Architect> in the quantities and formats as required under the general contract. In the absence of requirements, provide as described in the following with reference to quantity and format.

B. Failure to comply with requirements in part or whole shall constitute grounds for non-review and/or rejection of resubmittal packages.

C. Resubmittals: For resubmittals, include a cover letter that lists actions taken and revisions made to each product in response to the Engineer’s submittal review comments. Lack of this actions-taken cover letter shall constitute grounds for non-review and/or rejection of resubmittal packages.

D. Obtain written approval from the <Engineer><Owner> for the product data submittal, the shop drawing submittal, and other required pre-construction submittals prior to materials and equipment purchase order and prior to installation.

E. Submittal Description: Product Data
   1. Electronically submit the product data submittal via cloud-based project management application (such as Proliance) or as a file transfer (such as Dropbox).
   2. File Format:
      a. File format shall be PDF, either as a single compiled PDF file or as a PDF portfolio.
      b. PDF files should be produced from original electronic media, not scans of printed media. If scans from prints are the only option, annotate electronically, not on the prints prior to scanning.

c. Page size should be letter (8.5"x11").

3. Organization:
   a. Organize the Content in the following order:
      1) Cover
      2) Table of Contents (TOC)
      3) Statement of compliance
      4) Product information
      5) Seismic calculations (as required)
   b. Clearly and precisely indicate the submitted product and accessories by part number using an electronic annotation (arrow, rectangle, oval, etc.). Where the product data presents “part number builds”, list the exact part number of the submitted products and accessories.
   c. Add page numbers in numerical order with no gaps to each page that correctly correspond to the TOC.
   d. Add bookmarks to the file to improve navigation.
4. Content:
   a. Cover: Include a cover that clearly displays the following information:
      1) Owner name
      2) Project name and address
      3) Submittal name (e.g., “Product Data Submittal for Telecommunications Equipment Rooms”)
      4) Project submittal number
      5) Contractor’s submittal number (discretionary)
      6) Submittal date; format: Month Day, Year (e.g., “January 1, 2020”)
      7) Specification section numbers included in the submittal (e.g., “Section 271100”)
      8) Contractor name and contact information
   b. Table of Contents (TOC): Include a TOC that lists materials by section number, article and paragraph number. Add a brief product description (what it is, size or color or other optional features), manufacturer and part number. List the submittal page number per product. Example heading for TOC:

Section	Article	Paragraph	Description	Manufacturer	Part #	Page #

   c. Statement of Compliance: Include a “Statement of Compliance” letter or memorandum on the submitter’s company letterhead from the highest ranking employee assigned to this project stating the submittal has been reviewed (quality control check) and is in full compliance with the requirements of the contract documents, and listing the submittal’s contents. Wet sign (and stamped, if applicable) the letter.
   d. Product Information: Include manufacturer's technical data, product literature, "catalog cuts", data sheets, specifications, and block wiring diagrams (if necessary) that clearly describe the product’s characteristics, physical and dimensional information, electrical performance data, materials used in fabrication, material color and finish, and other relevant information such as test data, typical usage examples, independent test agency information, and storage requirements. Include products listed in the specifications, at a minimum. Include relevant products that will be installed, which are not listed in the specifications.
   e. Seismic Calculations: Include structural calculations for anchorage and seismic restraint of floor-mounted equipment (such as racks, frames, cabinets), wall-mounted equipment (such as video display equipment, etc.), and overhead-mounted equipment (such as cable tray, overhead cable support, etc.) in conformance with CBC, Chapter 16. Calculations shall be based on fully loaded equipment and support systems. Calculations shall demonstrate that the equipment and support systems will remain attached to the mounting surface

during and after experiencing seismic forces in conformance with the CBC. A Structural Engineer registered in the State of California shall prepare Structural Calculations and shall wet stamp and sign them. Obtain approval from <approving agency> for the calculations.

F. Submittal Description: Shop Drawings
   1. Electronically submit the shop drawings submittal via cloud-based project management application (such as Proliance) or as a file transfer (such as Dropbox).
   2. Format:
      a. Use the same sheet size as the contract drawings.
      b. Use the same title block as the contract drawings, modified to include contractor information.
      c. Text: 3/32" - 1/8" high when plotted at full size.
      d. Symbols should match those in the contract documents.
      e. Screen background information.
      f. Plot system components (symbols, outlet, devices, pathways, cable routes, etc.) and text using a heavier line weight sufficient enough to stand out against background information.
      g. Scaling:
         1) Scale floor plans and reflected ceiling plans at 1/8"=1'-0"
         2) Scale enlarged room plans at 1/4"=1'-0"
         3) Scale wall elevations at 1"=1'-0"
         4) Scale rack elevations at 1"=1'-0"
   3. Content:
      a. Cover Letter: Accompany each shop drawing submittal with a cover letter stating that the shop drawings have been thoroughly reviewed by the Contractor and are in full compliance with the requirements of the contract documents. Have the person who prepared the submittal sign (and stamped, if applicable) the cover letter and include a drawing index.
      b. Drawings: Shop drawing submittals shall consist of symbols list, point-to-point diagrams, block diagrams, riser diagrams, line diagrams, floor plans, reflected ceiling plans, enlarged room plans, wall and rack elevations, installation details, and other aspects of the system. Include detailed labeling examples for cables, outlets, termination apparatus, devices, equipment, etc.
      c. Seismic Calculations: Include structural calculations for anchorage and seismic restraint of floor-mounted equipment (such as racks, frames, cabinets), wall-mounted equipment (such as video display equipment, etc.), and overhead-mounted equipment (such as cable tray, overhead cable support, etc.) in conformance with CBC, Chapter 16. Calculations shall be based on fully loaded equipment and support systems. Calculations shall demonstrate that the equipment and support systems will remain attached to the mounting surface during and after experiencing seismic forces in conformance with the CBC. A Structural Engineer registered in the State of California shall prepare Structural Calculations and shall wet stamp and sign them. Obtain approval from <approving agency> for the calculations.

G. Submittal Description: As-Built Drawings
   1. As-built drawings shall accurately represent actual installed conditions and shall incorporate modifications made during construction.
   2. Electronically submit the as-built drawings submittal via cloud-based project management application (such as Proliance) or as a file transfer (such as Dropbox).
   3. Format:
      a. Electronic files shall include native format and plotted PDF files. The file names shall include the sheet number.

b. Use the same sheet size as the approved shop drawings.
c. Use the same title block as the approved shop drawings.
d. Text: 3/32" - 1/8" high when plotted at full size.
e. Use symbols identical to the symbols shown on the approved shop drawings.
f. Screen background information.
g. Plot system components (symbols, outlet, devices, pathways, cable routes, etc.) and text using a heavier line weight sufficient enough to stand out against background information.

4. Content:
   a. Title Sheet, including symbols list and sheet index
   b. Diagrams, such as (but not limited to) point-to-point diagrams, block diagrams, riser diagrams, line diagrams, and other diagrams that conceptually describe the system
   c. Floor Plans and Reflected Ceiling Plans: Scale plans at 1/8”=1’-0”. Plans shall show:
      1) Locations and identifiers of telecommunications outlets
      2) Routes, types, sizes, and quantities of pathways (such as cable trays, conduits, hangers, and other pathways)
   d. Enlarged Rooms Layouts: Applicable rooms: Entrance facilities, BDFs, IDFs. Room drawings shall show:
      1) Floor layouts – scaled at either 1/4"=1’-0" or 1/2"=1'-0", showing dimensioned placement of equipment cabinets/frames, rack bays, etc.
      2) Overhead layouts – scaled at either 1/4"=1'-0" or 1/2"=1'-0", showing dimensioned placement of overhead cable support (e.g., cable tray, cable runway, conduit sleeves, etc.)
      3) Rack elevations – scaled at 1"=1'-0", showing placement of termination apparatus and other equipment installed onto rack bays
      4) Wall Elevations – scaled at 1"=1'-0", showing dimensioned placement of termination apparatus (e.g., termination/crossconnect blocks>

H. Submittal Description: Operation and Maintenance (O&M) Manual
1. Quantity and Media: Submit O&M Manual as described in Division 01. In the absence of requirements given, submit one packaged O&M Manual set and one electronic copy.
2. Electronic Submission: Submit the product data submittal via cloud-based project management application (such as Proliance) or as a file transfer (such as Dropbox).
3. Electronic Format:
   a. File format shall be PDF, either as a single compiled PDF file or as a PDF portfolio.
   b. PDF files should be produced from original electronic media, not scans of printed media. If scans from prints are the only option, annotate electronically, not on the prints prior to scanning.
   c. Page size should be letter (8.5"x11") or full size for drawings.
   d. Insert bookmarks to improve navigation through the file.
4. Printed Format:
   a. Package contents in a 3-ring binder with front cover and spine clear pockets for insertion of the submittal information.
   b. Page size should be letter (8.5"x11") or tabloid (17"x11") for drawings.
   c. Include tabbed separators to improve navigation through the manual.
5. Content and Organization:
   a. Cover, showing the following information
      1) Owner name
      2) Project name and address
      3) Manual name (e.g., “Operation and Maintenance Manual for Telecommunications Cabling System”)
      4) Date; format: Month Day, Year (e.g., “January 1, 2020”)

5) Contractor name and contact information
b. Table of Contents (TOC)
c. Product information (the final approved product submittal and updates through construction)
d. As-built drawings (the final approved as-built submittal)
e. Seismic calculations (the final approved product submittal)
f. Warranty Information
1) Warranty certificate from the manufacturer and the contractor
2) Instructions on making a warranty claim during the warranty period
3) Contact information during the warranty period
4) Contact information beyond the warranty period for maintenance and related service
g. Manufacturer's instructions for system or component use
h. Instructions and requirements for proper maintenance (according to the manufacturer) and as to maintain warranty

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications
1. Five continuous years, minimum, design and manufacture of the materials and equipment specified herein.
2. Manufacturer(s) of products and equipment specified herein shall demonstrate that they have a quality assurance program in place to assure that the specifications are met. Include in the program, at a minimum, provisions for:
a. Incoming inspection of raw materials
b. In-process inspection and final inspection of the cable product
c. Calibration procedures of test equipment to be used in the qualifications of the product
d. Recall procedures in the event that out of calibration equipment is identified.
3. Conform to government standards on quality assurance for applications within these specifications.

B. Contractor Qualifications
1. A current, active, and valid and C7 or C10 California State Contractors License
2. Five, minimum, continuous years of experience
3. Five, minimum, completed projects of similar scope and cost
4. Evidence of technicians qualified for the work (such as successfully completed training by the cabling vendor or BICSI, etc.)
5. IBEW / CWA union affiliation

C. Materials
1. Materials, support hardware, equipment, parts comprising units, etc., shall be new, unused, without defects and of current manufacturer, materials
2. Use specified products and applications, unless otherwise submitted and approved in writing.

D. Regulatory Requirements
1. Work and materials shall conform to the latest rules of National Board of Fire Underwriters wherever such standards have been established and shall conform to the regulations of the State Fire Marshal, OSHA and the codes of the governing local municipalities. Work under Division 27 shall confirm to the most stringent of the applicable codes.

2. Provide the quality identified within these specifications and drawings when codes, standards, regulations, etc. allow Work of lesser quality or extent. The contract documents address the minimum requirements for construction.

E. Drawings
1. Follow the general layout shown on the contract drawings except where other work may conflict with the drawings.
2. Contract drawings for the work within this division are essentially diagrammatic within the constraints of the symbology applied.
3. Contract drawings do not fully represent the entire installation. Rather, they indicate the general route for pathways and cables and show general locations of outlets. Contract drawings might not expressly show every conduit, sleeve, hanger, etc.; regardless, a complete system is required.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Delivery
1. Do not deliver products to the site until protected storage space is available.
2. Coordinate materials delivery with installation schedule to minimize storage time at jobsite.
3. Deliver materials in manufacturer's original, unopened, undamaged packaging and containers with identification labels (name of the manufacturer, product name and number, type, grade, UL classification, etc.) intact.
4. Immediately replace equipment damaged during shipping at no cost to the Owner, so as not to impact the construction schedule.

B. Storage and Protection
1. Store materials in clean, dry, ventilated space free from temperature and humidity conditions (as recommended by manufacturer) and protected from exposure to harmful weather conditions.
2. Comply with manufacturer's storage requirements for each product. Comply with recommended procedures, precautions or remedies as described in the MSDS as applicable.
3. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.
4. Storage outdoors covered by rainproof material is not acceptable.
5. Provide heat where required to prevent condensation or temperature related damage.

C. Handling
1. Handle materials and equipment in accordance with manufacturer's written instructions. Handle with care to prevent damage, breakage, denting, and scoring.
2. Do not install damaged materials and equipment. Replace damaged equipment at no cost to the Owner.

1.8 SEQUENCING

1.9 OWNER'S INSTRUCTIONS

1.10 SCHEDULING

A. Unless otherwise specified, the construction schedules of the Sections within Division 27 may be combined into a single, overall schedule.

B. Do not proceed without written approval from the Owner or Owner's Representative for schedule of this Work.

1.11 PROJECT MANAGEMENT AND COORDINATION

A. Project Management and Coordination Services
   1. Provide a project manager for the duration of the project to coordinate this Work with other trades. Coordination services, procedures and documentation responsibility include, but are not limited to, the items listed in this section.
   2. Review of Shop Drawings Prepared by Other Subcontractors:
      a. Obtain copies of shop drawings for equipment provided by others that require telecommunication service connections or interface with work.
      b. Thoroughly review other trades' shop drawings to confirm compliance with the service requirements contained in the Division 27 contract documents. Document discrepancies or deviations as follows:
         1) Prepare memo summarizing the discrepancy
         2) Submit a copy of the specific shop drawing, indicating via cloud, the discrepancy
      c. Prepare and maintain a shop drawing review log indicating the following information:
         1) Shop drawing number and brief description of the system/material
         2) Date of the review
         3) Name of the individual performing the review
         4) Indication if follow-up coordination is required
   3. Should existing conditions prohibit construction progress as submitted and approved, coordinate the adjusted installed locations with the other contractors (AV, electrical, etc).

B. Concurrent Installation
   1. The network will be installed concurrent with the work of Division 27. Coordinate your work with the Owner's/network integrator's work. For example, coordinate scope and dates for rack and cabling (terminations) readiness to allow the network integrator to plan and schedule installation of the network equipment (for example, access switches).

C. Role of the Engineer
   1. The network will be installed concurrent with the work of Division 27. Coordinate your work with the Owner's/network integrator's work. For example, coordinate scope and dates for rack and cabling (terminations) readiness to allow the network integrator to plan and schedule installation of the network equipment (for example, access switches).

D. Use of Electronic Drawing Files
   1. Should the Contractor require the Engineer's electronic files to produce shop drawings and/or as-built drawings, the Engineer will require the Contractor sign a file release agreement.

1.12 START UP

1.13 COMMISSIONING

1.14 WARRANTY

A. As a minimum, warrant products and labor provided will, under normal use and service, be free from defects and faulty workmanship for period of <1 year><5 years> from the date of acceptance. During the warranty period the entire system shall be kept in operating condition at no additional material or labor costs to the Owner. Also refer to specific sections for additional warranty requirements that supersedes the project's minimum warranty.

B. Render service within 24 hours of system failure notification. Note deviations or improvements to this service at the time of bid and obtain written acceptance from the Owner, or Owner's Representative.

C. Manufacturers of the major system components shall maintain a replacement parts department and provide testing equipment when needed. Provide complete replacement parts within 24 hours during the warranty period.

D. Conformance to certain government standards on quality assurance may be required for some applications outlined in these specifications.

1.15 MAINTENANCE

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.

B. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the <Engineer> <Owner> <Project Manager> <General Contractor> in writing prior to ordering the material and performing installation work.

2.2 PRODUCT SUBMITTAL AT TIME OF BID

A. At the time of bid, include a list of major products in the Contract documenting the intended cabling system solution, AV equipment, etc.

2.3 SUBSTITUTIONS

A. Conform to the substitutions requirements and procedures outlined in <Division 01><Section <012500><012513>>.

B. Only one substitution for each product specified will be considered.

C. Where products are noted as “or equal”, a product of equivalent design, manufacture, and performance will be considered. Submit product data (product information, catalog cuts, pertinent test data, etc.) to substantiate that the product is in fact equivalent to that specified. The burden of proof that the substituted product is equivalent to the specified product rests with the Contractor. Whenever material, process or equipment is specified in accordance with an industry specification (ANSI, TIA, etc.), UL rating, or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, submit supporting test data to substantiate compliance.

D. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance. Materials, processes or equipment that, in the opinion of the Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when “or equal” follows the manufacturers' names or model number(s).

E. When the Engineer accepts a substitution in writing, it is with the understanding that the Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Do not provide substituted material, processes, or equipment without written authorization from the Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by the Engineer, are at the sole risk of the Contractor.

F. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the work, or from provisions of the specifications.

G. Pay expenses, without additional charge to the Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on self, subcontractor's or another Contractor's work.

PART 3 - EXECUTION

3.1 PERMITS AND INSPECTIONS

A. Obtain and pay for permits and inspections required for the work.

B. Furnish materials and execute workmanship for this work in conformance with applicable legal and code requirements.

C. Perform tests required herein, or as may be reasonably required to demonstrate conformance with the Specifications or with the requirements of legal authority having jurisdiction.

D. Arrange and pay for review/inspection from compliance officials responsible for enforcement of applicable codes and regulations to establish that the work is in compliance with requirements of reference codes indicated herein.

3.2 EXAMINATION

A. Verify existing conditions, stated under other sections, are acceptable for installation in accordance with manufacturer's instructions.

B. Verify cable routes and lengths prior to pulling cables. Immediately notify the Engineer if actual lengths are expected to exceed project’s maximum length requirement(s).

3.3 FIELD QUALITY CONTROL

A. Staffing: Provide a qualified foreman to supervise the crew performing the work and who is present at the job site at times work is being performed.

B. Construction Meetings: Participate in construction coordination meetings throughout the course of construction to review the progress and to resolve issues and conflicts. Prepare and distribute meeting agenda for telecommunication issues prior to, and meeting notes after meetings, in a format acceptable to the Owner. Publish meeting notes within 3 business days following the meeting.

C. Scheduling: Perform the work within the approved construction schedule. Keep the construction schedule current, based on the results of the construction meetings. At minimum, schedule shall document critical due dates, tasks, and milestones. Submit revised schedules for approval within 3 business days whenever there are modifications.

D. Inspection: Inspect the work after installation. Keep areas of work accessible and notify code authorities, or designated inspectors, of work completion ready for inspection. Document completion and inspection as required.

3.4 INSTALLATION

A. Complete work in conformance to applicable federal, state and local codes, and telephone standards.

B. Complete work in a neat, high-quality manner, relative to common industry practices, and in accordance to NECA “Standard of Installation”.

C. Coordinate the entire installation throughout the construction team (general contractor and subcontractors).

D. Manufacturer's Instructions: Comply with manufacturer's published installation instructions, product data, product technical bulletins, product catalog, and other instructions for installation. Maintain a file on the jobsite of MSDSs for each product delivered to jobsite packaged with an MSDS.

E. Adjusting: Make changes and revisions to systems to optimize operation for final use. Make changes to systems such that defects in workmanship are corrected and completed systems pass the minimum test requirements.

F. Protection: Protect installed products and finish surfaces from damage during construction.

G. Repair/Restoration: Replace or repair work completed by others that you deface or destroy. Pay the full cost of this repair/replacement. Repair defects prior to system acceptance.

3.5 CLEANING

A. Remove temporary coverings and protection of adjacent work areas. Remove unused, excess, and left over products, debris, spills, or other excess materials. Remove installation equipment.

B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.

C. Repair or replace damaged installed products.

D. Legally dispose of debris.

E. Clean installed products in accordance with manufacturer's instructions prior to Owner's, or Owner’s Representative’s, punch walk.

3.6 PUNCH WALKS AND PUNCH LISTS

A. Punching the work of individual sections of Division 27 may be combined when noted so.

B. Execute a punch walk with the Engineer and the Owner or Owner’s Representative to observe Work.

C. Develop a punch list for items needing correction. Issue this punch list to Engineer.

D. Correct the Work as noted on punch list.

E. Execute follow up punch walk with the Engineer and the Owner or Owner’s Representative to verify punch list items have been corrected.

3.7 SYSTEM ACCEPTANCE

A. Complete corrections (punch list items) prior to submitting acceptance certificate.

B. On completion of the acceptance test, submit system acceptance certificate to the Owner or Owner’s Representative requesting their signature and return of the certificate. Issue copies of the signed certificate back to the Owner or Owner’s Representative with copy to the Engineer.

3.8 TRAINING

A. After acceptance, schedule a time convenient with the Owner, or Owner's Representative, for instruction in the configuration, operation, and maintenance of the system.

B. <Refer to individual sections within Division 27 for additional training requirements.> <Provide 2 hours, minimum, of on site training by a factory-trained representative. Document dates and times of training, and submit a “sign in” sheet for individuals trained, as part of the close out documentation.>

END OF SECTION 27 00 00

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 27 05 26

COMMUNICATIONS GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Communications Grounding Backbone and bonding of communications infrastructure and equipment to Communications Grounding Backbone.

B. Related Sections
   1. Comply with the Related Sections requirements of Section 270000.
   2. Section 260526, “Communications Grounding Backbone system”

1.2 REFERENCES

A. Comply with the References requirements of Section 270000.

B. In particular or addition to the codes and standards listed in Section 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. NFPA 70, “National Electrical Code”, particularly the following Articles:
      a. Article 250: Grounding
      b. Article 770: Optical Fiber Cables and Raceways
      c. Article 800: Communications Systems
   2. Underwriters Laboratories, Inc. (UL) UL 467: Grounding and Bonding Equipment
   3. Electronic Industries Association/Telecommunication Industry Association:
      a. ANSI-TIA-607-C, “Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises”
   4. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. IEEE 467, “IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems”
      b. IEEE P1100, “IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems”

1.3 DEFINITIONS

A. Definitions as described in Section 270000 shall apply to this section.

B. In addition to those Definitions of Section 270000, the following list of terms as used in this specification defined as follows:
   1. “BCT”: Bonding Conductor for Telecommunications
   2. “CM” and “cmil”: Circular Millionths of an inch
   3. “GE”: Grounding Equalizer Conductor
   4. “MBRGB”: Main Building Reference Grounding Busbar
   5. “PBB”: Primary Bonding Busbar
   6. “SBB”: Secondary Bonding Busbar
   7. “TBB”: Telecommunications Bonding Backbone

8. “TBC”: Telecommunications Bonding Conductor
9.
10. "THHN”: Thermoplastic High Heat-resistant Nylon-coated

1.4 SYSTEM DESCRIPTION

A. Base Bid Work: The Work under this section includes furnishing materials, installation, and coordination through the General Contractor with other trades for a Communications Grounding Backbone and for bonding of telecommunications equipment and apparatus to the Communications Grounding Backbone.

B. Communications Grounding Backbone System: The Communications Grounding Backbone System contains grounding busbars, grounding conductors, bonding conductors, and connecting devices (including but not limited to pressure connectors, lugs, clamps, or exothermic welds). These components, upon completion of installation and testing, shall provide the means of a low impedance path to earth for unintentional and/or stray voltages or spurious signals present on telecommunications media and equipment. The Communications Grounding Backbone System will consist of the following aspects (refer to Drawings for additional information)
   1. PBB: Locate the PBB in the EF/BDF with the following connections:
      a. MBRGB, via BCT (refer to Drawings for wire size)
      b. Each TBB
      c. Ground bushings installed on each entrance conduit opening within the space, via TBC
      d. Overhead cable support within the space, via TBC
      e. Dedicated power panel’s ACEG within the space serving communication equipment, via TBC
      f. Metallic pathways (conduits, surface raceway, etc.) within the space, via TBC
   2. TBB: TBB(s) are the primary bonding conductor between the PBB and other SBBs provided throughout a single building. The length of TBBs shall not exceed 500 feet. The TBB shall route from the BDF through each of the IDFs bonding each of the SBBs to the PBB. Maintain TBB continuity and do not break continuity in order to bond to a SBB.
   3. SBB: Locate the SBB in each IDF with the following connections:
      a. TBB
      b. Building steel, via TBC
      c. Each entrance conduit into the space, via TBC and ground bushings
      d. Overhead cable support within the space,, via TBC
      e. Panelboard’s ACEG within the space serving telecommunication equipment, via TBC
      f. Metallic pathways (conduits, surface raceway, etc.) within the space, via TBC

C. Performance Criteria for the Grounding Backbone:
   1. Resistance from any point of the communication grounding backbone system to the ground electrode and to earth shall not exceed 20 Ohms.
   2. Field test resistance and document, both electronically and printed, measured values.

D. Bonding: Bonding consists of TBCs within telecommunications rooms from the PBB and SBBs to the following components:
   1. Rack bay
   2. Overhead cable support and vertical cable support
   3. Wall-mounted termination equipment
   4. Conduit ground bushings
   5. Exit pathways

6. Bonding jumpers between basketway, cable runway, and cable tray joints & splices, and between basketway/cable runway/tray and equipment racks

E. Conductor Gauge Criteria:
1. Size BCT as the greater of either 2,000 cmil per linear foot up to 3/0 AWG or the largest TBB.
2. Size TBB, and TBCs as 6 AWG minimum, then as 2,000 cmil per linear foot up to 3/0 AWG.

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 270000.

B. Submittal Requirements at Start Of Construction:
1. Product Data Submittal
2. Shop Drawing Submittal(s), if the Contractor's installation intent differs from the Contract Documents or the deign intent

C. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 270000.

D. Submittal Requirements at Closeout: Submit to the Owner at the time of project closeout the following and before certificate of final payment is issued.
1. Test Report: Submit computer-generated test records of measured resistance values for inclusion into the Operation and Maintenance Manual.
2. As-Built Drawings, consisting primarily of the Communications Grounding Backbone (not necessarily each bonded component or apparatus)

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 270000.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of Section 270000.

1.8 WARRANTY

A. Warrant Work to perform as described within this Section for a period of 1 year. Correct deficiencies within 24 hours of notification.

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Application: Suitable for indoor installation as a BCT, TBB, and/or TBC.

B. Type: THHN (or THWN)

C. Approvals:
   1. UL 83 as Type THHN
   2. Federal Specification A-A-59544, NEMA WC-5, UL-758

D. Conductor: soft drawn annealed copper, stranded

E. Gauge: Refer to System Description for conductor sizing criteria.

F. Insulation: PVC, high-heat and moisture resistant

G. Jacket: Nylon, abrasion, moisture, gasoline and oil resistant

H. Color: green

I. Flame Resistance: Meet the flame resistance requirements of IEEE 383, CSA FT-4 and UL VW-1.

2.2 SPLICE

A. Application: High-pressure compression type connectors shall be used for cable-to-cable and cable-to-ground rod connections.

B. Manufacturers:
   1. Panduit
      a. #HTCT250-250-1; “H-type” compression splice for #2 – 250MCM AWG
   2. Thomas & Betts
      a. #53000 series
   3. Or equal

2.3 CONNECTOR – “PARALLEL” TAP

A. Application: H-type thick wall compression tap, for making conductor–to–conductor (e.g., TBB-to-TBC) permanent connection (pigtailing, tapping, or splicing). Connectors shall be UL Listed.

B. Manufacturers:
   1. Panduit
      a. #HTCT2-2-1; “H-type” compression tap, run = #6-#2, tap = #2-#6.
      b. #HTCT250-2-1; “H-type” compression tap, run = #2-250MCM, tap = #6-#2
   2. Or equal

2.4 CONNECTOR – “C” TAP

A. Application: C-type copper thick wall compression tap, for making conductor–to–conductor (e.g., TBB-to-TBC) permanent connection (pigtailing, tapping, or splicing). Connectors shall be UL Listed.

B. Manufacturer:
   1. Panduit

a. #CTAPF4-12-C; CTAP for #6 AWG run –to– #6 AWG tap
b. #CTAPF2-12-C; CTAP for #2 AWG run –to– #6 AWG tap
c. #CTAPF1/0-12-L; CTAP for 1/0 AWG run –to– #6 AWG tap
d. #CTAPF2/0-12-Q; CTAP for 2/0 AWG run –to– #6 AWG tap
e. #CTAPF3/0-12-Q; CTAP for 3/0 AWG run –to– #6 AWG tap

2. Or equal

2.5 GROUNDING BUSBAR - TINNED

A. General: Busbar shall be UL listed.

B. Standards: Compliant to ANSI-J-607-A

C. Material: Solid copper, tinned cladding

D. Holes: Predrilled, compatible with standard NEMA bolt hole sizing and spacing and with ANSI-J-607-A recommendations for 2-hole lugs.

E. Mounting: Wall-mounted with standoffs. Standoffs shall insulate busbar from the mounting substrate.

F. Manufacturer:
1. Panduit
a. # GB4B0624TPI-1; busbar, 20”L x 4”W x ¼”T, PBB hole pattern
b. # GB4B0612TPI-1; busbar, 12”L x 4”W x ¼”T, PBB hole pattern
c. # GB2B0312TPI-1; busbar, 20”L x 2”W x ¼”T, SBB hole pattern
d. # GB2B0306TPI-1; busbar, 12”L x 2”W x ¼”T, SBB hole pattern
e. #GB2B0304TPI-1; busbar, 10”L x 2”W x ¼”T, SBB hole pattern
2. Or equal

2.6 CONNECTION TO STRUCTURAL STEEL

A. Application: Exothermic welds shall be used for cable-to-cable, cable-to-ground rod, and cable-to-structural steel.

B. Manufacturers:
1. Cadweld
a. Each particular type of weld shall use a kit unique to that type of weld
2. Or equal

2.7 CONNECTOR – COMPRESSION LUG

A. Application: Conductor-to-busbar and/or –rack (or other flat surfaces) connection

B. Type: compression lug, standard or long barrel, two-hole (1/4 inch diameter 5/8 inch on center)

C. Manufacturers:
1. Panduit
a. #LCC6-14JAW-L; for 6 AWG conductor
b. #LCC4-14ADW-L; for 4 AWG conductor

c. #LCC2-14AW-Q; for 2 AWG conductor
d. #LCC1-14AW-E; for 1 AWG conductor
e. #LCC1/0-14AW-X; for 1/0 AWG conductor
f. #LCC2/0-14AW-X; for 2/0 AWG conductor

2. Or equal

2.8 CONNECTOR – SPLIT-BOLT, MECHANICAL TYPE

A. Application: Conductor-to-conductor (or other round component) connection

B. Type: split-bolt mechanical connector

C. Material: high-strength copper alloy

D. Manufacturers:
1. Cooper B-Line
a. #WB2GC; split bolt bonding clamp
2. Panduit
a. #SBC3-C; split bolt bonding clamp for #6 to #3 conductor
3. Or equal

2.9 GROUND BUSHING

A. Refer to for ground bushing requirements.

B. Plated malleable iron body with 150 degree Centigrade molded plastic insulating throat and lay-in grounding lug.

C. Manufacturers:
1. OZ/Gedney BLG
2. Thomas & Betts #TIGB series
3. Or equal.

2.10 BONDING STRAPS

A. Cable Runway Bonding Straps
1. Application: makes multiple sections of cable tray conductively continuous
2. Conductor: Flexible braided straps with factory terminated connectors.
3. Manufacturers:
a. Chatsworth Products Inc
1) #12061-001
b. Cooper B-Line
1) #SB6691x7¾
c. OZ/Gedney
1) Type BJ
d. Thomas & Betts
1) #3840 series
e. Or equal

B. Cable Tray Bonding Straps
1. Application: makes multiple sections of cable runway conductively continuous

2. Conductor: Flexible braided straps with factory terminated connectors.
3. Manufacturers:
   a. Cooper B-Line
      1) #99-N1
   b. Thomas & Betts
      1) #FB95
   c. Or equal.

2.11 LABELS

A. Labels for Busbars
   1. Labels shall be machine-printable (such as by a laser printer or hand-held printer)
   2. Printable area should be approximately 2 inch wide x 0.5 inch high
   3. Printable area color shall be white
   4. Manufacturer:
      a. Panduit
         1) #C200X100FJJ; laser/ink jet labels, white – for busbars
      b. Or equal

B. Labels for Conductors
   1. Labels shall be machine-printable (such as by a laser printer or hand-held printer)
   2. Labels shall be adhesive-backed and have a self-laminating feature
   3. Printable area should be 1 inch wide x 0.5 inch high, or larger
   4. Printable area color shall be white
   5. Manufacturer:
      a. Panduit
         1) #S100X150YAJ; laser/ink jet labels, white – for #6 wires
         2) # S100X225YAJ; laser/ink jet labels, white – for #6 to #1/0 wires
      b. Or equal

2.12 MISCELLANEOUS

A. Wire Clamp
   1. Material: nylon, UV stabilized.
   2. Color: black
   3. Size: 0.25” holding diameter for 6 AWG; or size as required based on conductor size.
   4. Manufacturer:
      a. Richco Inc.
         1) #N4B-BLK
      b. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of Section 270000.

B. Work shall comply with the International Building Code, International Fire Code, National Electrical Code, UL 467, and ANSI-J-607-A standards, as well as local codes that may specify additional grounding and/or bonding requirements. If discrepancies between codes and/or

standards arise, codes shall prevail, and then the more stringent requirement shall prevail, and as directed by the AHJ.

C. Install components to manufacturer's instructions and recommendations and as required per UL listing.

D. Identify grounding and bonding conductors and components according to local codes.

E. Terminations must be accessible for inspection and maintenance during the life of the system.

3.2 EXAMINATION AND PREPARATION

A. Prior to the start of this section's work, examine pathways and communications rooms for completeness, compatibility with the work of this section, and readiness for connections with the work of this section.

3.3 INSTALLATION

A. BCT, TBB, and Conductors
   1. Install BCT, and TBB conductors in conduit and in a manner to protect them from physical damage.
   2. When routing BCT, or TBB conductors through metallic conduit 3 feet or longer, bond the conductor to the conduit at both ends using a #6 AWG bonding conductor as a pigtail, an irreversible connection (preferably exothermic weld) for the conductor-to-pigtail connection, and insulated ground bushings at the conduit ends.
   3. Install the BCT, or TBB conductor without splices.
      a. In the event that a splice is necessary, notify the Engineer in writing. Do not proceed with splicing work until the Engineer has accepted in writing the installation of a splice.
      b. Locate the splice in a telecommunications space and ensure accessibility.
      c. Perform the splice using an exothermic weld and an irreversible compression-type connector.
   4. Where shown on the drawings, connect grounding conductors to structural steel using exothermic welds. Each particular type of weld shall use a kit unique to that type of weld.

B. PBB and SBB Busbars
   1. Mount busbars as noted on Drawings and using insulating standoffs. If not noted on drawings, install busbars onto wall at 24 inches AFF located within 5 feet of backbone pathways or rack bay.

C. Panelboard Bonding
   1. Where a panelboard is located in the same communications room as a PBB/SBB and serves that room, provide TBC between busbar and that panelboard's Alternating Current Equipment Ground (ACEG) bus (where equipped) or the enclosure.

D. Bonding
   1. Provide TBC and appropriate grounding hardware between the nearest TMGB/TGB and the equipment racks / rack bay, overhead cable support, vertical cable support, telecommunication conduits, primary pathways that enter/exit the room (if applicable), and other metallic telecommunication infrastructure components. Refer to Drawings for additional information.

2. Minimum size: #6. If longer than 25 feet, size TBCs based on length using 2000 cmil per foot, up to 2/0 AWG.
3. Install TBCs in a manner that will protect them from physical and mechanical damage.
4. Routing:
   a. Route TBCs in the shortest possible path, using right angles for turns and routed parallel to building lines. Route on outside edges of wall plywood. Do not cut across the middle of the plywood taking space away from other equipment or components.
   b. Utilize a minimum 1-foot bend radius.
5. Connection to PBB/SBBs:
   a. Thoroughly clean busbars prior to attaching connectors to the busbar.
   b. Fasten connectors (e.g., lugs) to the busbar using matching size bolt, flat washer Belleville washer, and nut. Torque hardware set.
6. Rack Bay Bonding
   a. Refer to Drawings for detailed diagrammatic requirements for bonding the rack bay.
   b. Bond equipment racks, frames, frame bays, cabinets, server racks, and other similar support systems located within the same room or space as the PBB/SBB to the busbar.
   c. Use approved connectors for TBC-to-rack, -frame, and -cabinet connections.
   d. Rack bays may be bonded in series using either of the following configurations:
      1) Series: Provide a TBC from the SBB to the rack closest to the busbar; then provide a TBC to the other racks in the rack bay in series using a common lug/connection per rack. The rack shall not be used as a ‘conductor’ in the series connection.
      2) String: Provide one ‘main’ TBC from the SBB along the length of the rack bay, and provide a pigtail from the ‘main’ TBC per rack. Use an irreversible connection (such as “C” tap) for the ‘main’-to-pigtail connection.
7. Overhead and Vertical Cable Support Bonding
   a. Bond overhead and vertical cable support located within the same room or space as the PBB/SBB to the busbar.
   b. Provide either UL listed connectors and splice plates or UL Listed bonding strap to bond sections of overhead cable support for ground continuity. This requirement applies to cable traybasketrayrunway sections and junctions within a single telecommunication room.
8. Termination Field Bonding
   a. Bond termination blocks to the PBB/SBB within the same room or space. Termination blocks may be bonded in series, with the block closest to the PBB/SBB bonded to the busbar. Refer to Drawings for detailed diagrammatic requirements for bonding the termination blocks.
9. Metallic Surface Raceway Bonding
   a. Bond metallic surface raceways for telecommunications cabling to approved electrical ground located within the same room or space as the surface raceway.

3.4 LABELING

A. General Requirements
   1. Labeling, identifier assignment, and label colors shall conform to TIA/EIA-606-A Administration Standard and as approved by the Engineer before installation.
   2. Permanently label TBCs. Affix label as close as practical to each end of the conductor.

B. Label Format
   1. Provide permanent labels with machine-generated text; hand written labels will not be accepted.
   2. Labels on TBCs shall fully wrap around conductors with a self-laminating feature to provide permanent marking.

C. Identifier Assignment
   1. Separate label fields of the identifier with a hyphen.
   2. Assign identifiers according to current practice and as approved by the Engineer before installation.
   3. BCT and TBB
      a. First field: “BCT" or “TBB” (the conductor type).
      b. Second field: a unique sequential number, for example, “01”.
      c. Example: “TBB-01”
   4. Ground Busbars
      a. First field: “PBB” or “SBB” (the busbar type)
      b. Second field: the room’s identity (IDF identifier’s suffix) where the busbar is installed; for example, “3A2.1”.
      c. Example: “SBB-3A2.1”
   5. TBC:
      a. First field: “TBC” (the bonding conductor type).
      b. Second field: The room identity where TBC exists; for example: “A1.1”.
      c. Third field: A unique sequential number; for example: “01”, “02”, etc.
      d. Fourth field: describe the device, equipment, component, or raceway being bonded.
      e. Example: “TBC-A1.1-01 (RACK BAY)”

3.5 GROUNDING BACKBONE RESISTIVITY MEASUREMENT

A. Measure ground resistance from each ground busbar to earth; record measurement. Provide additional grounding electrodes, bonding, and other elements as required to comply with resistance limits specified in this Section.

B. Submit computer-generated records of measured resistance values to Engineer for approval and for inclusion into the Operation and Maintenance Manual.

3.6 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 270000. Punching the Work of this Section may be combined with punching the rooms.

B. Comply with system acceptance and certification requirements of Section 270000.

END OF SECTION 27 05 26

SECTION 27 05 28

COMMUNICATIONS BUILDING PATHWAYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Pathway systems within buildings to support low voltage systems - namely cable hangers and rated sleeves.

B. Base Bid Work:
1. Provide materials and labor, whether explicitly mentioned herein or not, needed for complete pathway systems to satisfy the requirements of this section and the related drawings. “Complete” shall include primary components, supports, seismic bracing, bonding straps (as required), etc., necessary for a complete installation. This specification lists major equipment but not every accessory, support, fastener, etc., needed to complete the work.
2. Install pathway systems in accordance with CEC, UL listing information, manufacturer’s instructions, compliant to local inspections and seismic restraint requirements, NECA’s “Standards of Installation” pertaining to general electrical installation practices and recognized industry practices, and in conformance to ANSI/TIA-569 standard and BICSI TDMM guidelines.
3. Cable Hanger Systems
   a. Provide a complete cable hanger system compliant with requirements of the CEC (in particular, compliant with the requirements of Article 300.11), in accordance with NECA’s “Standards of Installation” (pertaining to general electrical installation practices), compliant with applicable portions of NFPA 70B, in accordance with manufacturer’s instructions, and in accordance with recognized industry practices. A “complete system” shall include cable hangers, supports, anchors, fasteners, and other required accessories.
   b. Provide cable hangers between primary pathways (or telecommunications rooms) and work area pathways and/or outlet locations at intervals up to 48 inches on center per a given route, at transitions downward/upward, and within 24 inches of an outlet stub/outlet location.
   c. Supports:
      1) Provide dedicated supports for cable hangers. Do not support cable hangers on ceiling grid support wires. Do not share supports with other trades. Do not support hangers from ductwork, piping, or other equipment hangers.
      2) Support Wires:
         a) Support wires shall consist of #12 drop wire (or as approved) with integral clip and fastener (such as power-actuated deck pin, beam flange, or other fastener appropriate for the use).
         b) Secure support wires at both ends in accordance with CEC.
      3) Support Rods:
         a) Support rods shall consist of 1/4 inch (6.3mm) or 3/8 inch (9.5mm) threaded or smooth rod and concrete anchor or beam flange clip or angled flange clip (as required for attachment to the building structure).

4. Spiral Wrap
    a. Provide spiral wrap to support and dress cables from feed pathways to the point where the cables enter the furniture system.
5. Seismic Bracing: If required by code, provide seismic bracing and restraints to supports and pathways. Seismic bracing shall be approved by a structural engineer licensed in the state of California.

C. Related Sections
1. Comply with the Related Sections paragraph of section 270000.
2. Section 260533, “Raceways and Boxes for Electrical Systems”
3. Section 270533, “Communications Conduits and Boxes”
4. Section 270536, “Communications Cable Trays”
5. Section 270526, “Communication Bonding”
6. Section 271100, “Communication Rooms”
7. Section _, “Communications Firestopping”

1.2 REFERENCES

A. Comply with the References requirements of section 270000.

B. In additional to those codes, standards, etc., listed in 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
1. Underwriters Laboratories (UL)
    a. UL 5, “Standard for Surface Metal Raceways and Fittings”
    b. UL 5A, “Nonmetallic Surface Raceways and Fittings”
    c. UL 5C, “Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits”
2. Underwriters Laboratories (UL)
    a. UL 467, “Grounding and Bonding Equipment”

1.3 DEFINITIONS

A. Definitions of section 270000 apply to this section.

B. In addition to those Definitions of section 270000, the following list of terms as used in this Section defined as follows:
1. “Cable Hanger”: A cable support component often shaped (section view) similar to the letter J (thus gaining the nickname “J hanger”), metallic (most often steel) or non-metallic (most often thermoplastic); available in different sizes (to support different quantities of cables) and with different attachment hardware suiting multiple installation methods (e.g., wire support, beam flange clip, etc.).
2. “Cable Strap”: A flexible cable support that generally ‘wraps’ around cables and ‘latches’ into a fixed position, most often textile, available in different sizes (to support different quantities of cables) and with different attachment hardware suiting multiple installation methods (e.g., wire support, beam flange clip, etc.).
3. “CEC”: California Electrical Code (CCR Title 24 Part 3)
4. “Enclosure”: The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.
5. “J Hanger” and “J Hook”: nickname for cable hanger
6. “NEC”: National Electrical Code (NFPA 70)
7. “NFPA”: National Fire Protection Agency

8. “UL”: Underwriters Laboratories

1.4 SYSTEM DESCRIPTION

A. Clearances (minimum):
   1. From fluorescent light fixtures, or other EMI sources = 6 inches (150 mm)
   2. From any motor = 48 inches (1,220mm)
   3. From flue, hot water, steam line or other non-insulated heat sources = 12 inches (300 mm)

1.5 SUBMITTALS

A. General: Conform to Submittal requirements as described in section 270000.

B. Quantity: Furnish quantities of each submittal as noted in section 270000.

C. Submittal Requirements Prior to the Start of Construction:
   1. Product Data Submittal, showing product dimensions, fabrications materials, fabrication details, knockout sizes and locations, capacities, finishes, and accessories
   2. Shop Drawings Submittal, consisting of proposed changes to pathways (routes, types, sizes, etc.) compared to the contract documents
   3. Seismic Calculations for Anchoring and Bracing: Submit seismic calculations for support systems in conformance section 270000. Calculations shall be prepared and signed by a Structural Engineer registered in the state of California. If used, specify proof loads for drilled-in anchors.

D. Submittal Requirements at Close Out:
   1. As-Built Drawings, showing the routes/locations, dimensions, types, sizes, quantities, etc., of pathways/pathway devices.
   2. O&M Manual, including as-builts, a parts list, repair information, and detailing ongoing maintenance requirements

E. Substitutions
   1. Requests for substitutions shall conform to the general requirements and procedure outlined in section 270000.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of section 270000.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of section 270000.

1.8 WARRANTY

A. Comply with Warranty requirements of section 270000.

PART 2 - PRODUCTS

2.1 HANGERS AND STRAPS

A. Application: Suitable for indoor installation within ceiling space for the support of communications cables.

B. Hanger shall be rated for use in air handling space.

C. Hangers shall contain a closing loop, retainer, or latch to prevent cables from falling off the hanger.

D. Manufacturer, or equal:
   1. Eaton B-Line
      a. #BCH21-W2; for drop wire installation
      b. #BCH32-W2; for drop wire installation
      c. #BCH21; for wall installation
      d. #BCH32; for wall installation
   2. Panduit
      a. #JMJH2-X20; cable hanger

2.2 DROP WIRE

A. Application: Suitable for indoor installation within ceiling space into structure above (e.g., deck or slab) for the support of cable supports such as cable hangers.

B. Listings: UL 2043, for use in air handling spaces

C. Drop wire shall be equipped with pre-mounted ceiling clip, fastening pin, and pre-tied wire. Pin shall be 7/8". Wire shall be 12 gauge.

D. Manufacturer, or equal:
   1. Hilti #CC27 X-AL-H22P8T x ft. PT (100); drop wire assembly, "x" for length
   2. Armstrong #7891
   3. Dottie #CWC
   4. Garvin Industries
   5. Oregon Wire Products

2.3 DROP ROD

A. Application: Suitable for indoor installation within ceiling space into building structure above (e.g., deck or slab) for the support of cable supports such as cable hangers.

B. Listings: UL 2043, for use in air handling spaces

C. Zinc plated for corrosion resistance

D. Manufacturer, or equal:
   1. CEAS #01014801; "Stiffy" straight rod, 1-1/4" power-actuated pin, 48 inches (or configured as required per instance)

2.4 FIRE RATED SLEEVE

A. Application: Suitable as a sleeve for cables to pass through a full-height partition (e.g., gypsum or masonry) or floor (e.g., cast-in-place slab or concrete metal deck), and as a through-penetration fire stop system maintaining the fire rating of the penetrated partition.

B. Sleeves shall be re-enterable.

C. Sleeve system shall be tested in accordance with ASTM E 814 (ANSI/UL1479).

D. Sleeve system shall be UL Listed and shall bear a UL Classification marking.

E. Sleeve system shall match (or exceed) the partition's/floor's F and T rating.

F. Manufacturer:
   1. Specified Technologies Inc (STI)
      a. #EZDP44; "EZ Path Series 44" 4-inch square sleeve kit
      b. #EZDP144FK; "EZ Path Series 44" 4-inch square sleeve kit with kick plate
      c. #EZDG444; "EZ Path Series 44" 4-inch square kit with 4 sleeves and 1 grid
      d. #EZD44; "EZ Path Series 44" 4-inch square sleeve
      e. #EZP144W; "EZ Path Series 44" wall plates (1 pair) for EZD44 sleeve
      f. #EZP544W; "EZ Path Series 44" wall plates (1 pair) for up to 5 EZD44 sleeves
      g. #EZP144K; "EZ Path Series 44" kick plate for EZD44 sleeve
      h. #EZG844; "EZ Path Series 44" grid for 8 sleeves
      i. #TRK444; T-rating kit, for 4 Series 44 sleeves

2.5 SPIRAL WRAP

A. Application: Suitable for an indoor installation for the support of telecommunications cables from a feed pathway to furniture systems, or similar.

B. Material shall be flame retardant polyethylene (UL94V-0), or equivalent.

C. Color: Black.

D. Size: As required to support the given cable bundle size (e.g., 3/4" minimum).

E. Manufacturer, or equal:
   1. HellermannTyton
   2. Panduit

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of section 270000.

3.2 EXAMINATION AND PREPARATION

A. Prior to starting the work of this section, examine areas to receive pathways systems to verify conditions are ready for work and to verify conformance with manufacturer and specification tolerances. Notify the Owner's Representative in writing of conditions that would adversely affect the installation, or subsequent utilization, of the system. Do not proceed with installation until unsatisfactory conditions are corrected.

B. Prior to installation, plan routes and locations of pathway systems and coordinate with other trades (ductwork, plumbing, electrical raceways, wall construction, ceilings, etc.). Pathway systems shall not unnecessarily cross other trade's work, shall not prevent removal of ceiling tiles or panels, and shall not block access to mechanical or electrical equipment. Provide offsets as required to avoid obstruction of pathway systems with other trades.

3.3 INSTALLATION

A. Hangers and Straps
   1. Install hangers so they are accessible through the ceiling grid and are not blocked by other building infrastructure.
   2. Install hangers above ceiling grid to result in cables sag 6 to 12 inches (150 to 300 mm), minimum, above ceiling grid. Cables shall not rest on the ceiling grid and/or ceiling tiles.
   3. Where hangers have loops/retainers, close loop/retainer (latch after cable installation).

B. Fire Rated Sleeve
   1. Install the sleeves in strict accordance with the UL System drawing, with the approved shop drawings, and with the equipment manufacturer's instructions.
   2. Framed Walls – Pre-Framed and Cut-In
      a. Coordinate location of penetration with other trades such as framing (wall studs), electrical (lighting), mechanical (ducts), and other trades.
      b. For cut-in instances, cut wallboard to fit rated sleeve system – no more wallboard than is necessary to fit the system.
      c. Apply the factory-supplied gasket prior to the installation of the wall plates.
      d. Secure wall plates to sleeves per the equipment manufacturer's recommendations.
   3. Affix a label at each fire sleeve location onto the wall or floor – within 2 to 3 feet. Place label in a location that will not be obscured after cables get installed through the sleeve. Label shall describe the system's applicable ratings, such as F, T, and L ratings.

3.4 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of section 270000.

B. Comply with system acceptance and certification requirements of section 270000.

END OF SECTION 27 05 28

SECTION 27 05 33

COMMUNICATIONS BUILDING PATHWAYS – CONDUITS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Pathway systems within buildings consisting of conduit and boxes (outlet, device, pull, and other boxes) to support <low voltage systems> <telecommunications, television, paging, nurse call, security, and other signal (low voltage) systems>

B. Related Sections
   1. Comply with the Related Sections paragraph of Section 270000.
   2. Section 260533, “Raceways and Boxes for Electrical Systems”
   3. Section 270526, “Communication Bonding”
   4. Section 271100, “Communication Rooms”
   5. Section _, “Communications Firestopping”

C. Allowances:
   1. <allowances>

D. Unit Pricing:
   1. General: Costs shall include material, labor, shipping, tax, markups (overhead, profit, job expenses, bond), labeling, records, and as-built drawings for a complete and operating system.
   2. U270533-01:
      a. Cost to provide one _, which includes:
         1) <qty> <description>
         2) <qty> <terminations>
         3) Labeling (at both ends)
         4) Record documents
      b. <assumptions>
      c. Exclude the testing of Owner furnished equipment such as telephone handsets

E. Alternates:
   1. A270533-01:
      a. Cost to _.

1.2 REFERENCES

A. Comply with the References requirements of Section 270000.

B. In additional to those codes, standards, etc., listed in 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. American National Standards Institute (ANSI)
      a. ANSI C80.1, “Specifications for Rigid Steel Conduit, Zinc Coated”
      b. ANSI C80.3, “Specifications for Electrical Metallic Tubing”
      c. ANSI C80.6, “Electrical Intermediate Metal Conduit”

2. ASTM International
    a. ASTM A123, “Standard Specification of Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products”
    b. ASTM A653, “Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process”
    c. ASTM D1654, “Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments”
3. International Electronic Committee (IEC)
    a. ANSI/IEC 60529, “Degrees of Protection Provided by Enclosures (IP Code)”
4. National Electrical Manufacturer Association (NEMA)
    a. NEMA 250, “Enclosures for Electrical Equipment (1000 volts maximum)”
    b. NEMA FB 1, “Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable”
    c. NEMA OS 1, “Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports”
    d. NEMA OS 2, “Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports”
    e. NEMA OS 3, “Selection and Installation Guidelines for Electrical Outlet Boxes”
    f. NEMA TC 2, “Electrical Polyvinyl Chloride (PVC) Conduit”
    g. NEMA TC 3, “Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing”
    h. NEMA TC 7, “Smooth-Wall Coilable Electrical Polyethylene Conduit”
5. Underwriters Laboratories (UL)
    a. UL 1, “Flexible Metal Conduit”
    b. UL 6, “Electrical Rigid Metal Conduit -Steel”
    c. UL 50, “Enclosures for Electrical Equipment, Non-Environmental Considerations”
    d. UL 360, “Liquid-Tight Flexible Steel Conduit”
    e. UL 467, “Grounding and Bonding Equipment”
    f. UL 514A, “Metal Outlet Boxes”
    g. UL 514B, “Conduit, Tubing, and Cable Fittings”
    h. UL 514C, “Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
    i. UL 651, “Schedule 40 and 80 Rigid PVC Conduit”
    j. UL 797, “Electrical Metallic Tubing - Steel”
    k. UL 1242, “Electrical Intermediate Metal Conduit - Steel”
    l. UL 2024, “Signaling, Optical Fiber and Communications Raceways and Cable Routing Assemblies”

1.3 DEFINITIONS

A. Definitions of Section 270000 apply to this Section.

B. In addition to those Definitions of Section 270000, the following list of terms as used in this Section defined as follows:
1. “Backbox”: A box [*see* “Box”] used to house cable terminations, to house devices, and to interface with cords/equipment; a backbox is installed with walls (such as within the cavities of framed walls and/or cast-in-place within concrete walls) such that the outlet/device finish (e.g., the coverplate/faceplate) is flush with the wall finish
2. “Box”: A box (often 5-sided with 1 side open) manufactured of sheet metal with welded corners, drawn metal, cast metal, or nonmetallic material (thermoplastic) in accordance with NEMA OS 1 or NEMA OS 2 and installed in accordance with NFPA 70 Article 314; available in different sizes (volumes) and modular design configurations (gangable) that may be field assembled, one to another, to accommodate multiple devices; boxes may

be used as outlet boxes, device boxes, backboxes, junction boxes, or pull boxes, depending on their intended use, and handhole enclosures.

3. “CEC”: California Electrical Code (California Code of Regulations, Title 24 Part 3)
4. “Device Box”: A box [*see* “Box”] with provisions for attaching and housing electrical devices (switches, receptacles, or similar wiring devices) manufactured in accordance with NEMA OS 1 and NEMA OS 2 and installed in accordance with NFPA 70 Article 314; available in different sizes (volumes) and modular design configurations (gangable) that may be field assembled, one to another, to accommodate multiple devices
5. “EIMC”: Electrical Intermediate Metal Conduit – see “IMC”
6. “EMT”: Electrical Metallic Tubing type conduit, as defined in ANSI C80.3 and NFPA 70 Article 358 An unthreaded thinwall raceway, generally made of steel (ferrous) with protective coatings or aluminum (nonferrous), of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings (per NEC Article 358)“FMT: Flexible Metal Tubing type conduit, as defined in NFPA 70 Article 360
8. “Floor Box”: A box [*see* “Box”] used to house cable terminations, to house wiring devices, and to interface with cords/equipment; a floor box is a special purpose box installed with floors (such as cast-in-place within concrete) such that the box finish (e.g., the coverplate) is flush with the floor finish
9. “HDPE: High Density Polyethylene type conduit, as defined in NFPA 70 Article 353
10. “Innerduct”: A continuous cylindrical pipe fabricated of extruded thermoplastic, available in corrugated, smooth, or other wall types and in different sizes (to support different quantities of cables), generally to provide a separate pulling channel and physical protection for fiber, coaxial, and metallic cables in telecommunications and other networks, and used in multiple applications such as the following:
    a. within conduit to compartmentalize or create ‘sub-ducts’
    b. in cable tray to create an isolated pathway
    c. by itself as a pathway system
11. “IMC”: Intermediate Metal Conduit type conduit, as defined in ANSI C80.6 and NFPA 70 Article 342
12. “Junction Box”: A box used to join different runs of raceway (such as conduit) or cables, or both, and to provide space for the connection and branching of the enclosed conductors; most boxes can be used solely as junction boxes as long as they are used with an appropriate cover and with appropriate (code-required) access
13. “MaxCell”: a textile subduct product (also, fabric innerduct)
14. “LFMC”: Liquidtight Flexible Metal Conduit type conduit, as defined in NFPA 70 Article 353
15. “Outlet Box”: A box [*see* “Box”] used to house cable terminations (connectors, modular jacks, receptacles, or similar wiring interfaces) and to interface with cords/equipment
16. “NEC”: National Electrical Code (NFPA 70)
17. “NEMA”: National Electrical Manufacturers Association
18. “NFPA”: National Fire Protection Agency
19. “Pull Box”: A box used in a conduit-based pathway system to allow access to and enclose conduit ends for placing cables and to house the interface between duct banks segments
20. “RMC”: Rigid Metal Conduit type conduit, as defined in NFPA 70 Article 344 and ANSI C80.1
21. “RNC”: Rigid Nonmetallic Conduit type conduit, as defined in NFPA 70 Article 352 and as manufactured to NEMA TC 2 specifications
22. “Textile Subduct”: A continuous enclosed assembly fabricated of polymer-coated nylon fabric used in conduit to compartmentalize or create ‘sub-ducts’, available in different sizes and ‘cell’ counts (to support different quantities of cables); an example of textile subduct includes “Maxcell”
23. “UL”: Underwriters Laboratories

1.4 SYSTEM DESCRIPTION

A. The scope of work of this section includes planning and coordination with General Contractor and other trades of inside plant conduit pathway systems, furnishing necessary materials, and labor and associated services required to install these pathway systems. The scope of work includes innerduct/subducting within conduit.

B. The drawings do not explicitly show on plans each and every conduit run needed for the project. Apply the guidelines described in this section and on the drawings to support the cabling described in Division 27 and shown on the low voltage drawings, and provide reasonably inferred standard conduits, fittings, and products required to complete the conduit installation to meet the design intent.

C. The scope of work includes conduit, boxes, and related construction materials that may not be expressly specified herein or expressly called out on the drawings, such as: 1- and 2-hole straps, nail straps, clamps and clamp backs, strut clamps, U-bolts, pipe hangers, clip-in and bolted hangers, bushings, ground bushings, service entrance cap/weatherhead, pull rope/tape, etc.

D. The scope of work includes basic construction materials that may not be explicitly specified herein or called out on the drawings, such as: concrete anchors, inserts, and/or expansion bolts; concrete fasteners; powder-actuated pins; construction channel/strut; threaded rod; wood fasteners (lag screws); beam clamps; purlin clips; stud box supports/brackets; floor-mount box supports; T-bar ceiling box support bar; channel-mount box supports; bonding pigtails; drywall ring (for ring & string); etc.

E. Existing Conditions
   1. <existing conditions description>

F. Work Covered Under Other Sections
   1. <work description>.

G. Existing Conditions
   1. <existing conditions description>

H. Conduit Systems, including Pull Boxes
   1. Provide conduit systems in accordance with <CEC><NEC> (Chapter 3 and Article 250), UL listing information, manufacturer's instructions, and compliant to local inspections and seismic restraint requirements. Conduit systems shall conform to ANSI/TIA-569-B standard and BICSI TDMM guidelines. Complete shall include all reasonably inferred conduits, fittings, connectors, couplers, straps, pull boxes, supports, etc., necessary for a complete installation to meet the intended application whether noted, indicated or specified in the Contract Documents or not. Duct bank routes and pull and junction box locations and elevations shown on the Drawings are diagrammatic in nature. Field verify route prior to installation.
   2. Provide pull boxes as necessary to facilitate proper cable placement, including the following:
      a. no more than 180 degrees bend between placement points
      b. no more than 150-200 feet conduit length (depending on the total bend between end points)
      c. to meet AHJ requirements
   3. Seismic Bracing: Provide seismic bracing to conduit system (duct banks, pull boxes, etc). Seismic bracing shall be approved by a structural engineer licensed in the state of California.

4. Seismic Joints: Provide seismic joints to conduit at building seismic joints. Seismic joint configurations shall be approved by a structural engineer licensed in the state of California.
5. Expansion Joints/Fittings: Provide expansion joints and/or fittings to conduit where necessary. Expansion joints/fittings shall be approved by a structural engineer licensed in the state of California.
6. Conduit systems shall be mechanically and electrically continuous throughout. Where EMT and associated fittings are used as part of equipment grounding system, provide a bonding type locknut where hub type fitting terminates into a threadless opening and provide compression ring type fittings for terminating and coupling.
7. Minimum Conduit Size: Refer to drawings. If not noted on the drawings, the minimum conduit size shall be <19 mm (3/4")><25 mm (1")><32 mm (1.25")>.
8. When cast in concrete floors and/or walls, adhere to structural design requirements. Unless otherwise noted on the drawings, the largest trade size conduits shall not exceed 1/3 the floor or wall thickness, and conduits shall be spaced a minimum of three conduit diameters apart.
9. Bend radii for conduit trade sizes 63.5 mm (2-1/2") and larger shall be 10 times the conduit outside diameter (OD) and bend radii for conduit trade sizes 51 mm (2") and smaller shall be 8 times the conduit OD.
10. Provide transition couplings where dissimilar conduit types are joined.
11. Conduit bodies or 'condulets' (LBs, etc.) are prohibited for telecommunications and audiovisual cables.
12. For type EMT conduits:
    a. Provide steel (preferred) zinc plated or die cast set screw (or compression fittings). For set screw fittings, provide single screw fittings (e.g., 1-screw connectors and 2-screw couplers) for 37mm (1.5") and smaller conduits and provide double screw fittings (e.g., 2-screw connectors and 4-screw couplers) for 51mm (2") and larger conduits.
    b. When cast in concrete, embedded masonry, or installed in dry locations (as defined by <CEC> <NEC>), provide compression fittings and couplings.
    c. When installed in damp locations (as defined by <CEC><NEC>), provide rain-tight type fittings and couplings.
13. For types IMC and RMC conduits:
    a. Provide steel (preferred), zinc plated or die cast threaded fittings (set screw and/or bolt-on fittings are prohibited). Provide steel locknuts and metal bushings. Provide bonding type bushings where necessary for conductive continuity or for bonding to ground.
14. When attaching to concrete ceilings, provide vibration and shock resistant bases.
15. Conduit Straps: Provide steel straps – for interior applications, provide straps without spacers
16. At conduits entering into building from outside, provide duct plugs per duct.
17. For unused conduits, provide a mechanical-type seal/cap for protection and to keep the conduit free from debris.
18. Provide a <pull tape> <pull line> into each conduit/duct between pull points.
    a. Where boxes are exposed in damp or wet locations or located in hazardous areas, provide cast metal boxes with gasketed cast metal cover plates.
    b. Provide supports for pull (and junction) boxes independently of conduit system and directly to the structure above. Provide seismic bracing for pull boxes.
19. Labeling:
    a. Provide permanent labels on conduit ends and pull box lids.
20. Conduit Application
    a. At interior concealed or exposed applications, 4" and smaller, provide EMT type conduit, unless otherwise note. EMT is the he preferred conduit type.

b. In cast-in-place concrete, RNC and EMT types will be allowed for telecommunications and other low voltage systems.
c. IMC and RMC will be allowed for telecommunications and other low voltage systems with written approval from the Engineer.
d. LFMC is allowed for telecommunications (and other low voltage systems) only for short spans requiring flexible connections. When used, upsize LFMC 1 full trade size (to allow for a derating of the fill capacity).
e. FMC is not allowed for telecommunications (and other low voltage systems) without written approval from the Engineer.

I. Clearances (minimum):
1. From fluorescent light fixtures, or other EMI sources = 6 inches (150 mm)
2. From any motor, transformer = 48 inches (1,220mm)
3. From flue, hot water, steam line or other non-insulated heat sources = 12 inches (300 mm)
4. No conduit and/or supports shall encroach into ceiling height, head room of walkways, and/or doorways.

J. Penetrations:
1. When penetrating partitions and other construction assemblies, use approved methods.
2. When penetrating concrete walls (including shear walls) and/or floors, scan the area to be penetrated and core openings using methods approved by the structural engineer and by the AHJ. Obtain written approval for locations and means when not using methods included in the contract documents.
3. When penetrating fire rated assemblies, provide UL Classified and FM Approved fire rated systems in accordance with ASTM E814 (UL1479). Provide labels at both sides of the penetration. Refer to drawings for approved systems per application.
4. When penetrating acoustic rated assemblies, provide sealant to fill gaps, cavities, etc, to fully seal penetration.

K. Innerduct / Subducting
1. Provide innerduct/subducting within backbone conduits in accordance with <CEC> <NEC> and the UL listing information.
2. Refer to drawings for routes requiring innerduct/subducting and innerduct/subducting sizes and types.

L. Duct Plugs
1. <Provide duct plugs at conduit ends at building entrances.> / <Provide fillers in each used duct port.> / <Provide duct plugs where indicated on Drawings.>
2. Provide simplex plugs for each fiber optic cable within innerduct at each building entrance. Size the plug depending upon the inside diameter of the innerduct and the outside diameter of the cable.

M. Outlet Boxes
1. Provide outlet boxes and covers/rings (raised and/or flat) in accordance with <CEC> <NEC> Article 314 and NEMA OS 3. Ground and bond metal outlet boxes in accordance with NEC Article 250, Parts I, IV, V, VI, VII, and X.
2. Provide support for outlet boxes. Outlet boxes for telecommunications and audiovisual may share a support bracket (such as a stud span bracket) with electrical outlet boxes.

N. Poke-Thrus
1. Coring: Refer to section 038213 for concrete core drilling requirements.

2. Provide poke-thrus, covers, and related products in accordance with <CEC> <NEC> Article 314 and NEMA OS 3. Bond metal devices to ground in accordance with applicable portions of <CEC> <NEC> Article 250 (such as Parts I, IV, V, VI, VII, and X).
3. At poke-thrus shared with power service, provide separation means in accordance with <CEC> <NEC>.

O. Floor Boxes
1. Provide floor boxes, covers, and related products in accordance with <CEC> <NEC> Article 314 and NEMA OS 3. Bond metal boxes to ground in accordance with applicable portions of <CEC> <NEC> Article 250 (such as Parts I, IV, V, VI, VII, and X).
2. At floor boxes shared with power service, provide separation means in accordance with <CEC> <NEC>.

P. Alternate Work:
1. Describe alternate work, if any.

1.5 SUBMITTALS

A. General: Conform to Submittal requirements as described in Section 270000.

B. Quantity: Furnish quantities of each submittal as noted in Section 270000.

C. Submittal Requirements Prior to the Start of Construction:
1. Product Data: Submit product data showing manufacturer, part numbers, listings, fabrication materials, dimensions, capacities, finishes, knockout sizes and configuration, accessories, etc.
2. Shop Drawings: Submit shop drawings consisting of the following:
   a. Conduit layout/routes, supports locations, support details
   b. Highlight proposed changes to pathways (routes, types, sizes, etc.) compared to the contract documents
   c. Clearance variations and/or requests for exceptions
   d. Seismic bracing details (also see “Seismic Calculations” below)
   e. Instances of penetrations through fire and smoke rated barriers, including calling out firestopping type/UL System, size, quantity, and other relevant information
3. Seismic Calculations: Submit seismic calculations for support systems in conformance Section 270000. Structural Calculations shall be prepared and signed by a California Registered Structural Engineer. If used, specify proof loads for drilled-in anchors.

D. Submittal Requirements at Close Out:
1. As-Built Drawings, showing the routes, types, sizes, quantities, dimensions, etc., of pathways (backbone pathways, primary pathways, conduit – required; secondary such as hangers – not necessary)
2. O&M Manual, including as-built drawings, parts list (essentially final approved product data submittal), repair information, and maintenance requirements

E. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 270000.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of section 270000.

B. NEC Compliance: Comply with NEC, as applicable to construction and installation of conduit and boxes.

C. NFPA Compliance: Comply with NFPA 70B, “Recommended Practice for Electrical Equipment Maintenance” pertaining to conduit and boxes.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of section 270000.

1.8 WARRANTY

A. Comply with Warranty requirements of section 270000.

PART 2 - PRODUCTS

2.1 ELECTRICAL METALLIC TUBING (TYPE EMT) CONDUIT AND FITTINGS

A. Application: Products and assembled system shall be suitable for indoor applications, in accordance with the NEC Article 358

B. Type EMT Conduit:
1. Type EMT conduit shall be formed of cold rolled strip steel, electrical-resistance welded continuously along the longitudinal seam, and zinc coated after welding. Type EMT conduit bore shall be smooth and free of blisters, nicks or other imperfections which could mar cables.
2. Type EMT conduit shall be listed by a nationally recognized testing laboratory to UL 797, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent. Type EMT conduit shall meet ANSI C80.3 specifications.
3. Type EMT conduit shall be listed by a nationally recognized testing laboratory to UL Safety Standard 797 and UL Safety Standard 514B, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent. Type EMT conduit shall meet ANSI C80.3 specifications.
4. Type EMT conduit shall be recognized as a bonding conductor per NEC Article 250.118
5. Factory elbows and bends minimum bend radius shall be 48”.
6. Manufacturers – Type EMT Conduit:
    a. Allied Tube and Conduit Co (Electrical Group) “E-Z Pull” EMT conduit (Kwik-Fit EMT also acceptable)
    b. Cal Conduit Products “CalBrite” EMT conduit
    c. Republic Conduit
    d. Western Tube and Conduit Corp
    e. Or equal

C. Fittings for EMT:
1. Fittings (connectors, couplers, straps, accessories, etc.) shall be listed by a nationally recognized testing laboratory to UL 514B, and shall bear the UL label (stamped or molded - such markings shall be permanent).
2. Fittings shall be manufactured compliant to ANSI/NEMA FB 1.

3. Standard Set-Screw Fittings: fabricated of steel with zinc electro-plated finish. Die cast zinc / cast malleable iron fittings not acceptable. Set-screws shall be case-hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.
4. Compression Fittings: gland and ring compression type construction; fabricated of steel zinc plated or cast malleable iron; UL Listed as raintight and suitable for concrete
5. Manufacturers – Fittings for EMT
    a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co)
    b. Thomas & Betts Corp
    c. Or equal

D. Deflection/Expansion Sleeve:
1. Application: Deflection/expansion sleeve shall compensate for movement in any direction between two conduit ends and shall withstand occasional vibration transmitted to conduit by rotating equipment or vehicular traffic.
2. Deflection/expansion sleeve shall be listed by a nationally recognized testing laboratory to UL 514B and UL 467, and shall bear the UL label (stamped or molded - such markings shall be permanent).
3. Deflection/expansion sleeve shall be fabricated of an inner sleeve, bonding braid, a neoprene outer sleeve with internal flexible stainless steel braid and outer stainless steel bands, ended with couplings (for connection to conduits).
4. Deflection/expansion sleeve shall accommodate 0.75 inch (19mm) deflection, expansion, contraction, or parallel misalignment in any direction, shall allow up to 30 degree angular deflections, and shall be raintight.
5. Manufacturer – EMT Expansion/Deflection Sleeve:
    a. Cooper Crouse-Hinds XD series
    b. O-Z Gedney (Emerson Electric Co) DX series
    c. Or equal

E. Expansion Sleeve:
1. Application: Expansion sleeve shall compensate for parallel movement between two conduits.
2. Expansion sleeve shall comply with UL514.B and NEMA FB-1.
3. Expansion sleeve shall be fabricated of an inner steel sleeve with an oversized outer sleeve sealed with slip bushings, configured such that the outer sleeve can move over the inner sleeve. Sleeve shall come equipped with internal or external bonding braid and be ended with couplers suitable to connect to conduit ends.
4. Manufacturers – EMT Expansion Sleeve:
    a. Cooper Crouse-Hinds XJG-EMT series
    b. O-Z Gedney (Emerson Electric Co) TX series
    c. Or equal

2.2 INTERMEDIATE METAL CONDUIT (TYPE IMC) AND FITTINGS

A. Application: Products and assembled system shall be suitable for indoor applications, in accordance with the NEC Article 342

B. Type IMC Conduit:
1. Type IMC conduit shall be fabricated of hot dip galvanized steel. The conduit bore shall be smooth and free of blisters, nicks or other imperfections which could mar cables.
2. Type IMC conduit shall be listed by a nationally recognized testing laboratory to UL 1242, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent. Type IMC conduit shall meet ANSI C80.6 specifications.

3. Type IMC conduit shall be listed by a nationally recognized testing laboratory to UL Safety Standard 1242 and UL Safety Standard 514-B, and shall meet ANSI C80.6 specifications.
4. Type IMC conduit shall be recognized as a bonding conductor per NEC Article 250.118
5. Factory elbows and bends minimum bend radius shall be 48".
6. Manufacturers – Type IMC Conduit:
    a. Allied Tube and Conduit Co (Electrical Group) "Kwik-Couple" conduit
    b. Western Tube and Conduit Corp
    c. Or equal

C. Fittings for IMC:
1. Fittings, connectors, couplers, straps, accessories, etc., shall be listed by a nationally recognized testing laboratory to UL 514B, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent.
2. Fittings, connectors, couplers, straps, accessories, etc., shall be manufactured compliant to ANSI/NEMA FB 1
3. Fittings, connectors, couplers, etc., shall be threaded - raintight and concrete tight where required by application.
4. Standard threaded couplings, locknuts, bushings, and elbows shall be fabricated of steel or malleable iron. Locknuts shall be bonding type with sharp edges for digging into the metal wall of an enclosure. Three piece couplings: Electroplated, cast malleable iron.
5. Manufacturers – Fittings for IMC
    a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co)
    b. Thomas & Betts Corp
    c. Or equal

D. Deflection/Expansion Sleeve:
1. Application: Deflection/expansion sleeve shall compensate for movement in any direction between two conduit ends and shall withstand occasional vibration transmitted to conduit by rotating equipment or vehicular traffic.
2. Deflection/expansion sleeve shall comply with UL467 and UL514.
3. Deflection/expansion sleeve shall be fabricated of an inner sleeve, bonding braid, a neoprene outer sleeve with internal flexible stainless steel braid and outer stainless steel bands, ended with couplings (for connection to conduits).
4. Deflection/expansion sleeve shall accommodate 0.75 inch (19mm) deflection, expansion, contraction, or parallel misalignment in any direction, shall allow up to 30 degree angular deflections, and shall be raintight.
5. Manufacturer – EMT Expansion/Deflection Fitting/Sleeve:
    a. O-Z Gedney (Emerson Electric Co) DX series
    b. Thomas & Betts XD series
    c. Or equal

E. Expansion Sleeve:
1. Application: Expansion sleeve shall compensate for parallel movement between two conduits.
2. Expansion sleeve shall comply with UL514.B and NEMA FB-1.
3. Expansion sleeve shall be fabricated of an inner steel sleeve with an oversized outer sleeve sealed with slip bushings, configured such that the outer sleeve can move over the inner sleeve. Sleeve shall come equipped with internal or external bonding braid and be ended with couplers suitable to connect to conduit ends.
4. Manufacturers – IMC (and/or RMC) Expansion Sleeve:
    a. Cooper Crouse-Hinds XJG series
    b. O-Z Gedney (Emerson Electric Co) TX series
    c. Or equal

F. Expansion Sleeve At Box Termination:
   1. Application: Expansion sleeve shall compensate for parallel movement between a conduit and a junction box/enclosure.
   2. Expansion sleeve shall comply with UL514.B and NEMA FB-1.
   3. Expansion sleeve shall be sealed sleeve design fabricated of malleable or ductile iron heads and steel sleeve.
   4. Manufacturers – IMC (and/or RMC) Expansion Sleeve:
      a. O-Z Gedney (Emerson Electric Co) Type EXE series
      b. Or equal

2.3 RIGID METAL CONDUIT (TYPE RMC) AND FITTINGS

A. Application: Products and assembled system shall be suitable for indoor applications, in accordance with the NEC Article 344

B. Type RMC Conduit:
   1. Type RMC conduit shall be fabricated of steel, galvanized inside and out (e.g., hot dip galvanized). Pre-threaded conduit ends shall be hot dip galvanized after cutting. Type RMC conduit bore shall be smooth and free of blisters, nicks or other imperfections which could mar cables.
   2. Type RMC conduit shall be listed by a nationally recognized testing laboratory to UL 6, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent. Type RMC conduit shall meet ANSI C80.1 specifications.
   3. Type RMC conduit shall be listed by a nationally recognized testing laboratory to UL Safety Standard 6 and UL Safety Standard 514-B, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent. Type RMC conduit shall meet ANSI C80.1 specifications.
   4. Type RMC conduit shall be recognized as a bonding conductor per NEC Article 250.118
   5. Factory elbows and bends minimum bend radius shall be 48”.
   6. Manufacturers – Type RMC Conduit:
      a. Allied Tube and Conduit Co (Electrical Group) “Kwik-Couple” conduit
      b. Western Tube and Conduit Corp
      c. Or equal

C. Fittings for RMC Conduit:
   1. Fittings, connectors, couplers, bushings, straps, accessories, etc., shall be listed by a nationally recognized testing laboratory to UL 514B, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent.
   2. Fittings, connectors, couplers, bushings, straps, accessories, etc., shall be manufactured compliant to ANSI/NEMA FB 1.
   3. Fittings, connectors, couplers, bushings, etc., shall be threaded – rain-tight and concrete-tight where required by application.
   4. Fabrication Materials:
      a. Connectors, couplers, and similar fittings: steel/zinc (preferred), die cast zinc, or malleable iron; 3-piece couplings: electroplated, cast malleable iron.
      b. Locknuts: steel, zinc-coated; bonding type locknuts shall have sharp edges for digging into the metal wall of an enclosure (to establish conductive connection with enclosure)
      c. Insulating bushings: die cast zinc with thermoplastic liner rated >100 degree C
   5. Manufacturers – Fittings for RMC
      a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co)
      b. Thomas & Betts Corp
      c. Or equal

D. Deflection/Expansion Sleeve:
   1. Application: Deflection/expansion sleeve shall compensate for movement in any direction between two conduit ends and shall withstand occasional vibration transmitted to conduit by rotating equipment or vehicular traffic.
   2. Deflection/expansion sleeve shall comply with UL467 and UL514.
   3. Deflection/expansion sleeve shall be fabricated of an inner sleeve, bonding braid, a neoprene outer sleeve with internal flexible stainless steel braid and outer stainless steel bands, ended with couplings (for connection to conduits).
   4. Deflection/expansion sleeve shall accommodate 0.75 inch (19mm) deflection, expansion, contraction, or parallel misalignment in any direction, shall allow up to 30 degree angular deflections, and shall be raintight.
   5. Manufacturer – EMT Expansion/Deflection Fitting/Sleeve:
      a. O-Z Gedney (Emerson Electric Co) DX series
      b. Thomas & Betts XD series
      c. Or equal

E. Expansion Sleeve:
   1. Application: Expansion sleeve shall compensate for parallel movement between two conduits.
   2. Expansion sleeve shall comply with UL514.B and NEMA FB-1.
   3. Expansion sleeve shall be fabricated of an inner steel sleeve with an oversized outer sleeve sealed with slip bushings, configured such that the outer sleeve can move over the inner sleeve. Sleeve shall come equipped with internal or external bonding braid and be ended with couplers suitable to connect to conduit ends.
   4. Manufacturers – RMC (and/or IMC) Expansion Sleeve:
      a. Cooper Crouse-Hinds XJG series
      b. O-Z Gedney (Emerson Electric Co) TX series
      c. Or equal

F. Expansion Sleeve at Box Termination:
   1. Application: Expansion sleeve shall compensate for parallel movement between a conduit and a junction box/enclosure.
   2. Expansion sleeve shall comply with UL514.B and NEMA FB-1.
   3. Expansion sleeve shall be sealed sleeve design fabricated of malleable or ductile iron heads and steel sleeve.
   4. Manufacturers – RMC (and/or IMC) Expansion Sleeve:
      a. O-Z Gedney (Emerson Electric Co) Type EXE series
      b. Or equal

2.4 RIGID NONMETALLIC CONDUIT (RNC) AND FITTINGS – ELECTRICAL PVC CONDUIT (EPC) – SCHEDULE 40 AND SCHEDULE

A. Application: products and assembled system shall be suitable for indoor applications, in accordance with the NEC Article 352

B. Conduit and fittings shall be homogeneous polyvinylchloride (PVC) material free from visible cracks, holes or foreign inclusions. The conduit bore shall be smooth and free of blisters, nicks or other imperfections which could mar cables.

C. Conduit, fittings, and accessories shall be UL Listed, and shall bear (permanently stamped or molded on conduit and fittings) the UL label. Markings shall be permanent.

D. Conduit, fittings, and accessories shall be from a single manufacturer to assure system integrity.

E. Type RNC Conduit:
   1. Conduit shall comply with UL 651 and NEMA TC 2 types EPC-40 (schedule 40) or EPC-80 (schedule 80).
   2. Conduit shall include an integral bell fitting at one end.
   3. Factory elbows' and bends' minimum bend radius shall be 1,220 mm (48 inches).

F. Fittings for RNC:
   1. Fittings (couplings, connectors, adaptors, transition fittings, etc.) shall comply with UL 514B and NEMA TC 3.
   2. Fittings shall be slip-on type and solvent weld type.
   3. Factory fittings and bends minimum bend radius shall be 48".

G. Expansion Fitting:
   1. Expansion fittings shall be designed to compensate for length changes due to temperature variations in exposed conduit runs.

H. End Caps: Pre-manufactured water-tight end caps

I. PVC Solvent Cement
   1. Application: For use in outdoor and underground installations to permanently join PVC sections (conduit ends, couplers, etc)
   2. Safe for human skin contact and not deleterious to cable insulation
   3. Workable at temperatures from 40 to 100 degree F

J. Manufacturers:
   1. Allied Tube & Conduit
   2. Carlon
   3. JM Eagle
   4. Ridgeline Pipe Manufacturing
   5. Or equal

2.5 LIQUID-TIGHT FLEXIBLE METAL CONDUIT (TYPE LFMC) AND FITTINGS

A. Application: Products and assembled system shall be suitable for indoor applications, in accordance with the NEC Article 350

B. Type LFMC Conduit:
   1. Type LFMC conduit shall be fabricated in continuous lengths from of single strip, flexible continuous, interlocked, and double-wrapped steel; galvanized inside and outside; coated with liquid-tight jacket of flexible polyvinyl chloride (PVC).
   2. Type LFMC conduit shall be listed by a nationally recognized testing laboratory to UL 360, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent.
   3. Manufacturers:
      a. AFC Cable Systems, Inc. (a part of Atkore International)
      b. ANAMET Electrical (a.k.a., Anaconda Sealtite)
      c. Electri-Flex Company
      d. Southwire Company
      e. Or equal

C. Fittings for LFMC:
   1. Connector body and gland nut shall be of cadmium plated steel or cast malleable iron, with tapered, male, threaded hub; insulated throat and neoprene "O" ring gasket

recessed into the face of the stop nut. The clamping gland shall be of molded nylon with an integral brass push in ferrule.

2. Manufacturers – Fittings for LFMC
   a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co)
   b. Cooper Industries
   c. Thomas & Betts Corp
   d. Or equal

2.6 PULL TAPE

A. Application: for installing/placing low voltage cables into conduit/ducts

B. Description: flat, woven, polyester or Kevlar® tape
   1. Lubricated (for easy pulling and reduced friction)
   2. Durably printed with sequential footage or meter markings
   3. UV resistant, and resistant to rot and mildew
   4. Pulling strength: 273 kg (60lb), minimum
   5. Low elongation

C. Manufacturers:
   1. Neptco Inc MULTETAPE®
   2. Pacific Strapping Inc HERCULINE®
   3. Or equal

2.7 PULL STRING

A. Application: For use with manual or power fishing systems for light duty cable or tape pulling applications

B. Description: round, woven, polypropylene line
   1. Packaged in storage container with easy, quick, and tangle-free dispensing
   2. UV resistant, and resistant to rot and mildew
   3. Low elongation

C. Manufacturers:
   1. Ideal Industries Inc Powr-Fish® or Valu-Line™ poly pull line
   2. Klein Tools #56110 poly pull line
   3. Or equal

2.8 INDOOR TEXTILE SUBDUCT

A. Application: Suitable for an indoor installation within conduit (or other closed pathways systems) to create multiple ‘cells’ within the conduit for telecommunications cables installed during the same construction phase or in the future.

B. Materials: Manufactured from internally processed polyester and nylon resins, factory lubricated. Material shall be halogen-free.

C. Construction: Flexible engineered fabric subducting, stitched into multi-cell design. Cells shall come equipped with pulling tape/rope. Cells shall be color-coded via printing and/or stitching.

D. Rating: Riser fabric subducting shall meet UL2024A for flame propagation and smoke density values for general applications, and plenum fabric subducting shall meet UL2024A for flame propagation and smoke density values for use in air handling spaces.

E. Manufacturer:
   1. TVC Communications' "MaxCell", Riser Rated
      a. #MXR3456BK; 3" 3-cell textile subduct, black thread stripe
      b. #MXR3456RD; 3" 3-cell textile subduct, red thread stripe
      c. #MXR3456BL; 3" 3-cell textile subduct, blue thread stripe
      d. #MXR2003YL; 2" 3-cell textile subduct, yellow thread stripe
      e. #MXR2002PR; 2" 2-cell textile subduct, purple thread stripe
      f. #MXR2001WH; 2" 2-cell textile subduct, white thread stripe
      g. #MXRM3303BK; micro 3-cell textile subduct, black thread stripe
      h. #MXRM3302BK; micro 2-cell textile subduct, black thread stripe
      i. #MXRM3301BK; micro 1-cell textile subduct, black thread stripe
   2. TVC Communications' "MaxCell", Plenum Rated
      a. #MXP3456BK; 3" 3-cell textile subduct, black thread stripe
      b. #MXP3456RD; 3" 3-cell textile subduct, red thread stripe
      c. #MXP3456BL; 3" 3-cell textile subduct, blue thread stripe
      d. #MXP2003YL; 2" 3-cell textile subduct, yellow thread stripe
      e. #MXP2002PR; 2" 2-cell textile subduct, purple thread stripe
      f. #MXP2001WH; 2" 2-cell textile subduct, white thread stripe
      g. #MXPM3303BK; 3-cell textile subduct for 1.25" C min, black thread stripe
      h. #MXPM3302BK; 2-cell textile subduct for 1.25" C min, black thread stripe
      i. #MXPM3301BK; 1-cell textile subduct for 1" C min, black thread stripe
   3. Or equal

2.9 INDOOR INNERDUCT – CORRUGATED TYPE, RISER RATED

A. Application: Suitable for an indoor installation within a riser system and/or other building conduits for the support of communications cables.

B. Innerduct:
   1. Material: Capron resin, or equivalent.
   2. Construction: continuously extruded corrugated piping, with a pull tape

C. Pull Tape:
   1. Material: yarn woven into a tape, pre-lubricated
   2. Tensile rating: 900 lb, minimum

D. Rating: UL 2024, and listed for riser and general purpose use according to NEC articles 770 and 800.

E. Manufacturers:
   1. A-D Technologies
   2. Carlon "Riser Guard" series innerduct
   3. Endot "Endocor/RI" series innerduct
   4. Pyramid "Fire Flex Riser Duct" series innerduct
   5. Or equal

F. Manufacturers:
   1. A-D Technologies
      a. #; 0.75" ID indoor riser-rated innerduct, corrugated

b. #; 1.00” ID indoor riser-rated innerduct, corrugated
c. #; 1.25” ID indoor riser-rated innerduct, corrugated

2. Carlon
   a. #DEX1C; 0.75” ID indoor riser-rated innerduct, corrugated, orange, with pull tape
   b. #DEX5C; 0.75” ID indoor riser-rated innerduct, corrugated, blue, with pull tape
   c. #DEX4C; 0.75” ID indoor riser-rated innerduct, corrugated, white, with pull tape
   d. #DFX1C; 1.0” ID indoor riser-rated innerduct, corrugated, orange, with pull tape
   e. #DFX5C; 1.0” ID indoor riser-rated innerduct, corrugated, blue, with pull tape
   f. #DFX4C; 1.0” ID indoor riser-rated innerduct, corrugated, white, with pull tape
   g. #DG4X1C; 1.25” ID indoor riser-rated innerduct, corrugated, orange, with pull tape
   h. #DG4X5C; 1.25” ID indoor riser-rated innerduct, corrugated, blue, with pull tape
   i. #DG4X4C; 1.25” ID indoor riser-rated innerduct, corrugated, white, with pull tape
3. Endot
   a. #0750RI; 0.75” ID indoor riser-rated innerduct, corrugated
   b. #1050RI; 1.0” ID indoor riser-rated innerduct, corrugated
   c. #1250RI; 1.25” ID indoor riser-rated innerduct, corrugated
4. Or equal

2.10 INDOOR INNERDUCT – CORRUGATED TYPE, PLENUM RATED

A. Application: Suitable for an indoor installation within a riser system, building conduits, ceiling space, and access floor spacefor the support of communications cables.

B. Innerduct:
   Carlon = PVDF resin, with pull tape
   1. Material: PVDF resin, or equivalent.
   2. Construction: continuously extruded corrugated piping, with a pull tape

C. Pull Tape:
   Carlon = ¼” wide tape, pre-lubricated, 900lb
   1. Material: yarn woven into a tape, pre-lubricated
   2. Tensile rating: 900 lb, minimum

D. Rating: UL 2024, and listed for plenum, riser, and general purpose use according to NEC articles 770 and 800.

E. Manufacturers:
   1. Carlon “Plenum Guard” series innerduct
   2. Endot “Endocor/PL” series innerduct
   3. Pyramid “Fire Flex Plenum Duct” series innerduct
   4. Or equal

F. Manufacturers:
   1. Carlon
      a. #CE4X1C; 0.75” ID indoor plenum-rated innerduct, corrugated, orange, with pull tape
      b. #CE4X5C; 0.75” ID indoor plenum-rated innerduct, corrugated, blue, with pull tape
      c. #CE4X4C; 0.75” ID indoor plenum-rated innerduct, corrugated, white, with pull tape
      d. #CF4X1C; 1.0” ID indoor plenum-rated innerduct, corrugated, orange, with pull tape
      e. #CF4X5C; 1.0” ID indoor plenum-rated innerduct, corrugated, blue, with pull tape
      f. #CF4X4C; 1.0” ID indoor plenum-rated innerduct, corrugated, white, with pull tape

g. #CG4X1C; 1.25” ID indoor plenum-rated innerduct, corrugated, orange, with pull tape
h. #CG4X5C; 1.25” ID indoor plenum-rated innerduct, corrugated, blue, with pull tape
i. #CG4X4C; 1.25” ID indoor plenum-rated innerduct, corrugated, white, with pull tape

2. Endot
   a. #0750PL; 0.75” ID indoor plenum-rated innerduct, corrugated
   b. #1050PL; 1.0” ID indoor plenum-rated innerduct, corrugated
   c. #1250PL; 1.25” ID indoor plenum-rated innerduct, corrugated
3. Or equal

2.11 INNERDUCT – SMOOTH-WALL TYPE, LSZH

A. Application: Suitable for installation within spaces and areas requiring no release of halogen gas by products due to fire, for the support of communications cables.

B. Construction: continuously extruded smooth wall piping, with a poly pull rope

C. Manufacturers:
1. A-D Technologies “Fire-Guard LSZH” series innerduct
2. A-D Technologies
   a. #; 0.75” ID indoor riser-rated innerduct, corrugated
   b. #; 1.00” ID indoor riser-rated innerduct, corrugated
   c. #; 1.25” ID indoor riser-rated innerduct, corrugated
3. Or equal

2.12 DUCT PLUGS

A. Application: Suitable for installation within conduits at termination/end entering into underground maintenance holes/pull boxes and into buildings from underground/exterior, opening into a telecommunications space. Duct plugs shall provide a watertight (up to 20 psi) seal around innerducts and cables.

B. Duct plugs shall be sized per conduit trade/actual size, per innerduct trade/actual size, and per cable outside diameter – as required per instance.

C. Duct plugs shall be re-enterable and re-usable.

D. Manufacturers:
1. Tyco (JACKMOON)
   a. #298182 (JM-BLA-10D104U); blank plug for 1-inch trade size duct | duct ID: 0.96”-1.16” (24.4mm-29.5mm)
   b. #187308 (JM-BLA-12D148U); blank plug for 1.25-inch trade size duct | duct ID: 1.14”-1.48” (29.0mm-37.6mm)
   c. #036620 (JM-BLA-15D183U); blank plug for 1.5-inch trade size duct | duct ID: 1.49”-1.83” (37.8mm-46.5mm)
   d. #923104 (JM-BLA-20D236U); blank plug for 2-inch trade size duct | duct ID: 1.83”-2.36” (46.5mm-59.9mm)
   e. #162754 (JM-BLA-30D346U); blank plug for 3-inch trade size duct | duct ID: 2.99”-3.46” (75.9mm-87.9mm)
   f. #377850 (JM-BLA-40D402U); blank plug for 4-inch trade size duct | duct ID: 3.94”-4.17” (100mm-106mm)

g. #260212 (JM-SIM-40S118S); simplex plug for 4-inch trade size duct | duct ID: 3.93-4.16” (102.1-105.9mm), port size: 1.06-1.18” (26.9-30.0mm)
h. #453996 (JM-SIM-40S136S); simplex plug for 4-inch trade size duct | duct ID: 3.93-4.16” (102.1-105.9mm), port size: 1.19-1.36” (30.2-34.5mm)
i. #738840(JM-SIM-40S196SB); simplex plug for 4-inch trade size duct | duct ID: 3.93-4.16” (102.1-105.9mm), port size: 1.38-1.96” (35.1-49.8mm)
j. #E64616 (JM-SIM-10S020SB); fiber optic cable simplex plug for 1-inch trade size duct | duct ID: 1.00-1.14” (25.4-29.0mm), port size: 0.08-0.20” (2.0-5.1mm)
k. #186120 (JM-SIM-10S035S); fiber optic cable simplex plug for 1-inch trade size duct | duct ID: 1.00-1.14” (25.4-29.0mm), port size: 0.27-0.35” (6.9-8.9mm)
l. #A87868 (JM-SIM-10S035SB); fiber optic cable simplex plug for 1-inch trade size duct | duct ID: 1.00-1.14” (25.4-29.0mm), port size: 0.20-0.35” (5.1-8.9mm)
m. #032536 (JM-SIM-10S057SB); fiber optic cable simplex plug for 1-inch trade size duct | duct ID: 1.00-1.14” (25.4-29.0mm), port size: 0.35-0.57” (8.9-14.5mm)
n. #D36745 (JM-SIM-10S065S); fiber optic cable simplex plug for 1-inch trade size duct | duct ID: 1.00-1.14” (25.4-29.0mm), port size: 0.55-0.65” (14.0-16.5mm)
o. #341608 (JM-QUA-40Q136S); quadplex plug for 4-inch trade size duct | duct ID: 4.02-4.17” (102.1-105.9mm), port size: 1.19-1.36” (30.2-34.5mm)
p. #336906 (JM-QUA-40Q142S); quadplex plug for 4-inch trade size duct | duct ID: 4.02-4.17” (102.1-105.9mm), port size: 1.36-1.42” (34.5 - 36.1mm)

2. TVC Communications’ “MaxCell” Duct Plug Accessories
   a. #MXCTP4; duct plug for 4” conduit, has 9 holes (3 - 0.7” ID, 3 - 0.9” ID, 3 - 1.1” ID)
   b. #MXCTBSET070; bushing sleeves for cables 0.31” to 0.65” OD into 0.7” ID plug holes
   c. #MXCTBSET090; bushing sleeves for cables 0.31” to 0.84” OD into 0.9” ID plug holes
   d. #MXCTBSET110; bushing sleeves for cables 0.31” to 1.02” OD into 1.1” ID plug holes
3. TVC Communications’ “MaxCell” Duct Sealing Bag Accessories
   a. #MXCITB3; inflatable termination bag for 3” conduit
   b. #MXCITB4; inflatable termination bag for 4” conduit
   c. #MXCITT; inflation termination tool
   d. #MXCIGC; CO_2 cartridge for inflation termination tool
4. Or equal

2.13 PULL BOXES

A. Application: For use indoors as cable placement point (pull box) for low voltage cabling and wiring within a conduit raceway system.

B. Compliances:
   1. Pull boxes shall meet the requirements of UL 50 and NEMA Type 1.
   2. Pull boxes shall be listed by a nationally recognized testing laboratory for the purpose.

C. Material and Finish:
   1. Thickness: 16 gauge, minimum
   2. Material: the following materials are acceptable for pull boxes
      a. Pre-galvanized steel (ASTM A653), then formed
      b. Mild steel formed, then hot-dipped galvanized (per ASTM A123)
      c. Mild steel formed, then painted (polyester or epoxy powder coat, meeting ASTM D1654)

D. Size: pull box size shall comply with <CEC> <NEC> 314.28

E. Configuration: pull boxes shall --- Covers shall be secured by machine screws at 6 inches intervals.

F. Manufacturers:
1. Cooper B-Line (Eaton)
2. Hoffman (Pentair)
3. Hubbell Wiegmann (SC Series enclosures, as an example)
4. Or equal

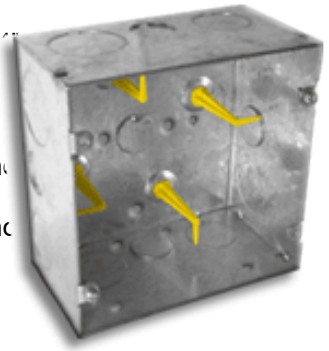
2.14 STEEL OUTLET BOXES AND COVERS

A. Application: For use indoors as outlet box, backbox, and/or junction box of low voltage systems to house wiring, cabling, terminations, and connectors; may also house and support components.
1. Outlet boxes shall permit access to conductors for maintenance
2. Outlet boxes shall come with knock-outs or punch-outs for easy creation of holes to accept conduit connectors.

B. Compliances:
1. Outlet boxes shall meet the requirements of <CEC> <NEC> Article 314.
2. Outlet boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, for remote control circuits, and for telecommunications circuits in accordance with NEC Article 314.
3. Outlet boxes shall be manufactured compliant to NEMA: FB-1 and OS-1.
4. Outlet boxes shall be fire resistant and suitable for use in rated spaces (reference: UL Fire Resistance Directory / “Orange Book”).

C. Material and Finish:
1. Material: <AISI/SAE 1008 Steel> <hot rolled, pre-galvanized steel, minimum spangle, AISI C-1008>
2. Thickness: <CEC> <NEC> 314.40(B) / 1.59 mm (0.0625in), minimum
3. Finish: G60 hot dip zinc galvanized (0.60 oz/sq ft), meeting ASTM A123, or pre-galvanized (continuous sheet galvanizing) meeting per ASTM A653
4. Finish Thickness: ~0.0005 inches

D. Square Box and Covers/Rings – 5”
1. Dimensions: 5 in square x 2.875 in deep
2. Volume: 64 in^3
3. Outlet box shall come equipped with integrated cable management/slack support.
4. Manufacturers:
   a. Randl Industries
      1) #T-55017; “5 Square” outlet box, knockouts: one 1” + one 1-1/4” per side, one 1/2” per back
      2) #T-55018; “5 Square” outlet box, knockouts: one 1/2", + one 3/4” per side, one 1/2” per back
      3) #T-55019; “5 Square” outlet box, knockouts: one 1/2", + two 1” 1/2” per back
      4) #T-55057; “5 Square” outlet box with side mounting bracket, kn 1” + one 1-1/4” on 3 sides, one 1/2” per back
      5) #T-55058; “5 Square” outlet box with side mounting bracket, kn 1/2", + one 3/4” + one 1” on 3 sides, one 1/2” per back



6) #T-55059; “5 Square” outlet box with side mounting bracket, knockouts: one 1/2", + two 1” on 3 sides, one 1/2” per back
7) #R-55000; blank cover for “5 Square” outlet box
8) #N-54000; 4”-sq cover for “5 Square” outlet box, flat
9) #N-54012; 4”-sq cover for “5 Square” outlet box, 1/2" raised
10) #N-54058; 4”-sq cover for “5 Square” outlet box, 5/8" raised
11) #N-54034; 4”-sq cover for “5 Square” outlet box, 3/4" raised
12) #N-54010; 4”-sq cover for “5 Square” outlet box, 1" raised
13) #N-54114; 4”-sq cover for “5 Square” outlet box, 1-1/4" raised
14) #N-54112; 4”-sq cover for “5 Square” outlet box, 1-1/2" raised
15) #D-51G000; one gang cover for “5 Square” outlet box, flat
16) #D-51G012; one gang cover for “5 Square” outlet box, 1/2" raised
17) #D-51G058; one gang cover for “5 Square” outlet box, 5/8" raised
18) #D-51G034; one gang cover for “5 Square” outlet box, 3/4" raised
19) #D-51G010; one gang cover for “5 Square” outlet box, 1" raised
20) #D-51G114; one gang cover for “5 Square” outlet box, 1-1/4" raised
21) #D-52G000; two gang cover for “5 Square” outlet box, flat
22) #D-52G012; two gang cover for “5 Square” outlet box, 1/2" raised
23) #D-52G058; two gang cover for “5 Square” outlet box, 5/8" raised
24) #D-52G034; two gang cover for “5 Square” outlet box, 3/4" raised
25) #D-52G010; two gang cover for “5 Square” outlet box, 1" raised
26) #D-52G114; two gang cover for “5 Square” outlet box, 1-1/4" raised

b. Or equal

E. Square Box – 4-11/16”, Extra Deep

1. Dimensions: 4-11/16 in square x 3 (or 3-1/4) in deep
2. Volume: 66.7 in^3
3. Box shall have standard 4-11/16 screw pattern (accept standard 4-11/1 rings/tile covers/etc).
4. Knock-outs: top, bottom: 3/4 in to 2 in; sides: 3/4" to 1-1/4”
5. Manufacturers:
   a. Gavin Industries
      1) #72181-1-1/4; 4-11/16" square x 3" deep box, welded
   b. RACO (Hubbell Electrical Products)
      1) #260; 4-11/16" square x 3-1/4" deep box, welded
      2) #981; Partition for 4-11/16" square x 3-1/4" deep box, and raised covers
   c. Or equal

F. Square Box – 4-11/16”, Deep

1. Dimensions: 4-11/16 in square x 2-1/8 in deep
2. Volume: 42 in^3
3. Box shall have standard 4-11/16 screw pattern (accept standard 4-11 rings/tile covers/etc).
4. Manufacturers:
   a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co
   b. Garvin Industries #72171-1-1/4 drawn 4-11/16”S x 2-1/8”D box
   c. RACO (Hubbell Electrical Products)
   d. Steel City (Thomas & Betts)
   e. Or equal

G. Square Box – 4”, Super Deep

1. Dimensions: 4 in square x 3-1/2 in deep
2. Volume: 46 in^3

3. Box shall have standard 4-square screw pattern (accept standard 4-sq covers/mud rings/tile covers/etc).
4. Manufacturers:
   a. Steel City (Thomas&Betts) # 521911234
   b. Or equal

H. Square Box – 4", Deep
1. Dimensions: 4 in square x 2-1/8 in deep
2. Volume: 30.3 in^3
3. Box shall have standard 4-square screw pattern (accept standard 4- rings/tile covers/etc).
4. Manufacturers:
   a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric C
   b. Garvin Industries
   c. RACO (Hubbell Electrical Products)
   d. Steel City (Thomas & Betts)
   e. Or equal

I. Masonry Box, Deep
1. Dimensions: 3-1/2 in deep x 3-3/4 in long x [1-7/8 in wide (1 gang) or 3-3/4 gang) or 5-1/2 in wide (3-gang)]
2. Box shall have standard 4-square screw pattern (accept standard 4-sq cove rings/tile covers/etc).
3. Manufacturers:
   a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co)
   b. Garvin Industries
      1) #TB-135
      2) # TB-135; one-gang masonry box
      3) # TB-235; two-gang masonry box
      4) # TB-335; three-gang masonry box
   c. RACO (Hubbell Electrical Products)
   d. Steel City (Thomas & Betts)
      1) #1-BM; one-gang masonry box
      2) #2-BM; two-gang masonry box
      3) #3-BM; three-gang masonry box
   e. Or equal

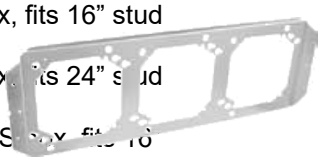
2.15 BOX SUPPORT ACCESSORIES

A. Box accessories shall comply with UL standards and shall be listed by a nationally recognized testing laboratory.

B. Stud-Mount Single-Box Bracket
1. Erico #SGBS16A; stud-mount bracket, for 1-1/2" or 2-1/8"D box, fits 16" stud sp
2. Erico #SGBS24A; stud-mount bracket, for 1-1/2" or 2-1/8"D box, fits 24" stud sp
3. Garvin #BMB16218; stud-mount bracket, for 2-1/8"D box, fits 16" stud spacing
4. Garvin #BMB16350; stud-mount bracket, for 3-1/2"D box, fits 16" stud spacing
5. Garvin #BMB24218; stud-mount bracket, for 2-1/8"D box, fits 24" stud spacing
6. Garvin #BMB24350; stud-mount bracket, for 3-1/2"D box, fits 24" stud spacing
7. Garvin #BMB16SL; stud-mount bracket, 'sliding' position for 1-1/2" or 2-1/8" D box, fits 16" stud spacing
8. Garvin #BMB24SL; stud-mount bracket, 'sliding' position for 1-1/2" or 2-1/8" 24" stud spacing

9. Raco #9004; fixed stud-mount bracket, for 2-1/8”D box, fits 16” stud spacing
10. Raco #9006; fixed stud-mount bracket, for 2-1/8”D box, fits 24” stud spacing
11. Raco #9013; adjustable stud-mount bracket, for 2-1/8”D box, fits 10-3/8” to 18” stud spacing
12. Raco #9015; adjustable stud-mount bracket, for 2-1/8”D box, fits 15” to 26” stud spacing

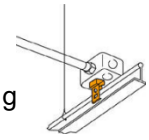
C. Stud-Mount Multi-Box Bracket
1. Erico #RBS16; stud-mount bracket, 3 positions for 4S and/or 4-11/16”S box, fits 16” stud spacing
2. Erico #RBS24; stud-mount bracket, 4 positions for 4S and/or 4-11/16”S box, fits 24” stud spacing
3. Garvin #BMB4S3P; stud-mount bracket, 3 positions for 4S and/or 4-11/16”S box, fits 16” stud spacing
4. Raco #9002; stud-mount bracket, 3 positions for 4S and/or 4-11/16”S box, fits 16” stud spacing
5. Raco #9002; stud-mount bracket, 4 positions for 4S and/or 4-11/16”S box, fits 24” stud spacing



D. Floor-Mount Box Mounting Bracket
1. Erico #FMBS18; floor mount support bracket for box, puts box at 18.5” above wall footer
2. Garvin #KP4-12; floor mount support bracket for 4S and/or 4-11/16”S box, puts box at 12” above wall footer
3. Garvin #KP4-18; floor mount support bracket for 4S and/or 4-11/16”S box, puts box at 18” above wall footer
4. Garvin #KP4-24; floor mount support bracket for 4S and/or 4-11/16”S box, puts box at 24” above wall footer
5. Raco #9009; floor mount support bracket for 4S and/or 4-11/16”S box, puts box at 12” above wall footer
6. Raco #9010; floor mount support bracket for 4S and/or 4-11/16”S box, puts box at 18” above wall footer

E. T-Bar Bracket
1. Erico #510HD; bracket for outlet box, attaches to T-bar ceiling grid

F. T-Bar Support
1. Erico #4ACS; adapter/support for outlet box, attaches to T-bar ceiling g



2.16 MULTIPURPOSE FLOOR BOXES

A. Application:
1. Indoor use as a multi-service (audiovisual, telecommunications, power) outlet box to house wiring, cabling, termination, connectors, and receptacles
2. Cast concrete floor, slab-on-grade, and/or raised access floor
3. Carpet, tile, wood, bare (polished) concrete, and terrazzo floor finishes

B. Compliances:
1. Floor boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, and remote control) circuits and for telecommunications circuits in accordance with NFPA 70 Article 314 for use in tile, terrazzo, carpet, and wood covered floors.
2. Cover assemblies shall meet UL requirements under UL514A for scrub water exclusion for use in tile, terrazzo, carpet, and wood covered floors.

3. Floor boxes shall be listed by a nationally recognized testing laboratory as suitable for use in air handling spaces in accordance with Sec 300-22(c) of the NEC.

C. Fire Rating:
1. Floor boxes shall be listed by a nationally recognized testing laboratory and Fire Classified to U.S. safety standards. UL fired rated up to 2-hour rated floors.
2. Floor boxes shall provide two-hour fire rating to maintain the fire classification of the floor.
3. Floor boxes shall be suitable for use in air handling spaces in accordance with Sec 300-22(c) of the NEC.

D. Load Capacity: Floor box assembly (back box, cover, etc) shall be rated to 1,800 lbs static load.

E. Material and Construction: steel (14 gauge), continuous seam welded

F. Cover Finish: <coordinate cover/trim with architect> <brass> <brushed aluminum> <black>

G. Features:
1. <6> <8> <10> gangs
2. Knock-outs (or punch-outs) for easy creation of holes to accept conduit connectors
3. Permit access to conductors behind terminations (for maintenance)
4. Accept AAP connector/adapter plates

H. Manufacturers:
1. Wiremold
a. #EFB6S; “Evolution” floor box, 6-gang, standard
b. #EFB6S-OG; “Evolution” floor box, 6-gang, on-grade
c. #EFB6S-FC; “Evolution” floor box, 6-gang, fire class
d. #EFB8S; “Evolution” floor box, 8-gang, standard
e. #EFB8S-OG; “Evolution” floor box, 8-gang, on-grade
f. #EFB8S-FC; “Evolution” floor box, 8-gang, fire class
g. #EFB10S; “Evolution” floor box, 10-gang, standard
h. #EFB10S-OG; “Evolution” floor box, 10-gang, on-gra
i. #EFB10S-FC; “Evolution” floor box, 10-gang, fire cla
2. Or equal

2.17 MULTI-SERVICE FLOOR BOXES

A. Application: For use indoors as a multi-service (telecommunications, audiovisual, power) outlet box to house wiring, cabling, termination, connectors, and receptacles installed within a cast concrete floor

B. Box Construction: Seam welded 14 gauge steel

C. Compliances:
1. Floor boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, and remote control) circuits and for telecommunications circuits in accordance with NFPA 70 Article 314 for use in tile, terrazzo, carpet, and wood covered floors.
2. Floor box assemblies shall meet the scrub water exclusions requirements of UL 514A for use in tile, terrazzo, carpet, and wood covered floors.

D. Load Capacity: Floor box assembly (back box, cover, etc) shall be rated to 300 lbs (minimum) static load.

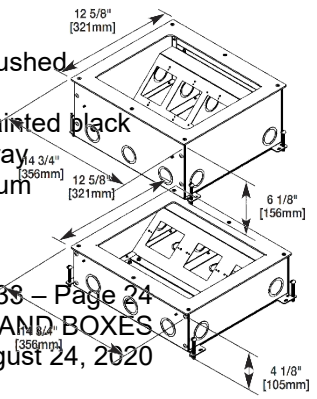
E. Features:
1. Suitable for cast-in-place concrete applications
2. 8 gangs, minimum
3. Knock-outs (or punch-outs) for easy creation of holes to accept conduit connectors
4. Permit access to conductors behind terminations (for maintenance)

F. Cover Finish: Coordinate with Architect

G. Manufacturers:
1. FSR Inc.

   a. #FL-500P-2.25; c-i-p floor box, 2.25-in depth
   b. #FL-500P-3; c-i-p floor box, 3-in depth
   c. #FL-500P-4; c-i-p floor box, 4-in depth
   d. #FL-500P-6; c-i-p floor box, 6-in depth
   e. #FL-500P-8; c-i-p floor box, 8-in depth
   f. #FL-500P-10; c-i-p floor box, 10-in depth
2. FSR Inc.

   a. #SF-PB; 'SmartFit' c-i-p floor box (round), 4-in diameter x 5.9
   b. #SF-DDP; sub-plate for 4" box – two decora openings
   c. #SF-2SDP; sub-plate for 4" box – one decora, one 5-20R electrical outlet, and
      keystone ports
   d. #SF-IPSPS; sub-plate for 4" box – IPS interface (3 position) and one 5-20R
      electrical outlet
   e. #SF-BC-CV; type/finish? cover for 4" box, carpet applications
   f. #SF-BLKC-CV; type/finish? cover for 4" box, carpet applications
   g. #SF-SC-CV; type/finish? cover for 4" box, carpet applications
   h. #SF-BT-CV; type/finish? cover for 4" box, tile applications
   i. #SF-BLKT-CV; type/finish? cover for 4" box, tile applications
   j. #SF-ST-CV; type/finish? cover for 4" box, tile applications
3. Hubbell

   a. #CFB7G4; c-i-p floor box, 4 in depth, 7 gangs
   b. #CFB7G6; c-i-p floor box, 6 in depth, 7 gangs
   c. #CFB7CVRBRS; brass cover for 7-gang floor box, 1/4" edging
   d. #CFB7CVRALU; aluminum cover for 7-gang floor box, 1/4" edging
   e. #CFB7TBRS; brass cover for 7-gang floor box, 1/2" edging
   f. #CFB7TALU; aluminum cover for 7-gang floor box, 1/2" edging
   g. #CFB11G4; c-i-p floor box, 4 in depth, 11 gangs
   h. #CFB11G6; c-i-p floor box, 6 in depth, 11 gangs
   i. #CFB11CVRBRS; brass cover for 11-gang floor box, 1/4" edging
   j. #CFB11CVRALU; aluminum cover for 11-gang floor box, 1/4" edging
   k. #CFB11TBRS; brass cover for 11-gang floor box, 1/2" edging
   l. #CFB11TALU; aluminum cover for 11-gang floor box, 1/2" edging
4. Wiremold


   a. #RFB-11; c-i-p floor box, 6 in depth, 11 gangs
   b. #RFB-9; c-i-p floor box, 4 in depth, 9 gangs
   c. #RFB119CTCAL; cover for carpet floors, with carpet cut-out area, brushed aluminum
   d. #RFB119CTCBK; cover for carpet floors, with carpet cut-out area, painted black
   e. #RFB119CTCGY; cover for carpet floors, with carpet cut-out area, gray
   f. #RFB119BTCAL; cover for flush tile or carpet floors, brushed aluminum
   g. #RFB119BTCBK; cover for flush tile or carpet floors, painted black

h. #RFB119BTCGY; cover for flush tile or carpet floors, gray

5. Or equal

2.18 MULTI-SERVICE FLOOR BOXES

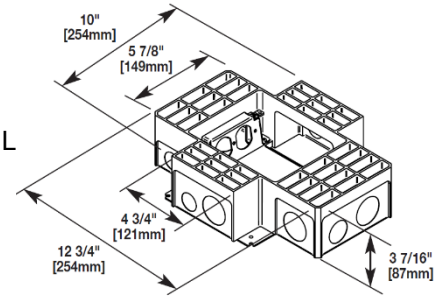
A. Application: For use indoors as a multi-service (telecommunications, power) outlet box to house wiring, cabling, termination, connectors, and receptacles within a cast concrete floor
   1. Floor boxes shall permit access to conductors for maintenance
   2. Floor boxes shall come with knock-outs or punch-outs for easy creation of holes to accept conduit connectors.

B. Compliances:
   1. Floor boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, and remote control) circuits and for telecommunications circuits in accordance with NFPA 70 Article 314 for use in tile, terrazzo, carpet, and wood covered floors.
   2. Floor box assemblies shall meet the scrub water exclusions requirements of UL 514A for use in carpet and wood covered floors.

C. Construction: Seam welded 14 gauge steel.

D. Cover Finish: Coordinate with Architect.

E. Manufacturer:
   1. Wiremold
      a. #RFB-4; c-i-p floor box, 3-7/8 in depth, 4 gangs
      b. #RFB2-OG; two-compartment floor box, 6-1/2” W x 13-1/8” L
      c. #RFB22AB; internal communication bracket
   2. Or equal



2.19 MULTI-SERVICE POKE-THRUS

A. Application: For use indoors as a multi-service (telecommunications, audiovisual, power) outlet to house wiring, cabling, termination, connectors, and receptacles
   1. Poke thrus shall permit access to conductors for maintenance.

B. Compliances:
   1. Poke thrus shall be listed by a nationally recognized testing laboratory for the purpose.
   2. Poke thrus shall comply to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, and remote control) circuits and for telecommunications circuits in accordance with NFPA 70 Article 314 for use in tile, terrazzo, carpet, and wood covered floors.
   3. Poke thrus shall meet (or exceed) UL 514A requirements for scrub water test.

C. Fire Rating:
   1. Poke thrus shall be listed by a nationally recognized testing laboratory as a rated penetrating device.
   2. The poke-thru outlet shall maintain the rating of the concrete slab/deck within allowable penetration methods.
   3. Poke thrus shall provide at least two-hour fire rating.

D. Load Capacity: Floor box assembly (back box, cover, etc) shall be rated to 300 lbs (minimum) static load.

E. Construction:
   1. Body shall be fabricated of steel (or die cast) non-flammable materials.
   2. Body shall include integral intumescent material for firestopping feature.
   3. Stubs shall be fabricated of listed EMT.
   4. Boxes shall fabricated of welded steel and shall be listed for the purpose.

F. Cover Finish: Coordinate with Architect.

G. Manufacturer:
   1. FSR
      a. SmartFit series
      b. #SF-PK1.5; 4” poke thru, with one 1” and one 1.5” EMT stub, j-box, no cover
      c. #SF-PK1; 4” poke thru, with two 1” EMT stubs, j-box, no cover
      d. #SF-DDP; sub-plate for 4” poke thru – two decora openings
      e. #SF-2SDP; sub-plate for 4” poke thru – one decora, one 5-20R electrical outlet, and two keystone ports
      f. #SF-IPSPS; sub-plate for 4” poke thru – IPS interface (3 position) and one 5-20R electrical outlet
      g. #SF-BC-CV; type/finish? cover for 4” poke thru, carpet applications
      h. #SF-BLKC-CV; type/finish? cover for 4” poke thru, carpet applications
      i. #SF-SC-CV; type/finish? cover for 4” poke thru, carpet applications
      j. #SF-BT-CV; type/finish? cover for 4” poke thru, tile applications
      k. #SF-BLKT-CV; type/finish? cover for 4” poke thru, tile applications
      l. #SF-ST-CV; type/finish? cover for 4” poke thru, tile applications
      m. #SF6-PT; 6” poke thru, with one 1” and one 1.5” EMT stub, j-box, no cover
      n. #SFR-PT-JNC1; 8” poke thru, with one 1” and one 1.5” EMT stub, j-box, no cover
      o. #SFR-PT-JNC1-ALM; 8” poke thru, with one 1” and one 1.5” EMT stub, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, brushed aluminum cover assembly
      p. #SFR-PT-JNC1-BLK; 8” poke thru, with one 1” and one 1.5” EMT stub, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, black aluminum cover assembly
      q. #SFR-PT-JNC1-BRS; 8” poke thru, with one 1” and one 1.5” EMT stub, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, brushed brass cover assembly
      r. #SFR-PT-JNC2; 8” poke thru, with two 1” EMT stubs, j-box, no cover
      s. #SFR-PT-JNC2-ALM; 8” poke thru, with two 1” EMT stubs, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, brushed aluminum cover assembly
      t. #SFR-PT-JNC2-BLK; 8” poke thru, with two 1” EMT stubs, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, black aluminum cover assembly
      u. #SFR-PT-JNC2-BRS; 8” poke thru, with two 1” EMT stubs, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, brushed brass cover assembly
      v. #SFR-PT-JNC3; 8” poke thru, with one 2” EMT stub, j-box, no cover
      w. #SFR-PT-JNC3-ALM; 8” poke thru, with one 2” EMT stub, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, brushed aluminum cover assembly
      x. #SFR-PT-JNC3-BLK; 8” poke thru, with one 2” EMT stub, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, black aluminum cover assembly

y. #SFR-PT-JNC3-BRS; 8” poke thru, with one 2” EMT stub, j-box, two dual pre-wired NEMA 5-20R electrical receptacle sub-plates, brushed brass cover assembly
z. #SFR-CVR-ALM; aluminum finish cover assembly for 8” poke thru
aa. #SFR-CVR-BLK; black aluminum cover assembly for 8” poke thru
bb. #SFR-CVR-BRS; brass cover assembly for 8” poke thru

2. Hubbell
   a. SystemOne series
   b. #S1PTBRS; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 2 decora/GFCI openings, brushed brass universal carpet cover
   c. #S1PTAL; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 2 decora/GFCI openings, brushed aluminum universal carpet cover
   d. #S1PTBL; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 2 decora/GFCI openings, black universal carpet cover
   e. #S1PTGY; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 2 decora/GFCI openings, gray universal carpet cover
   f. #S1PT3IMBRS; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 1 “INFINeSTATION” opening and 1 NEMA 5-20R, brushed brass universal carpet cover
   g. #S1PT3IMAL; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 1 “INFINeSTATION” opening and 1 NEMA 5-20R, brushed aluminum universal carpet cover
   h. #S1PT3IMBL; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 1 “INFINeSTATION” opening and 1 NEMA 5-20R, black universal carpet cover
   i. #S1PT3IMGY; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 1 “INFINeSTATION” opening and 1 NEMA 5-20R, gray universal carpet cover
   j. #S1PT4X4BRS; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 4 Keystone port and 4 NEMA 5-20R, brushed brass universal carpet cover
   k. #S1PT4X4AL; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 4 Keystone port and 4 NEMA 5-20R, brushed aluminum universal carpet cover
   l. #S1PT4X4BY; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 4 Keystone port and 4 NEMA 5-20R, black universal carpet cover
   m. #S1PT4X4GY; 4” poke thru, with one 1” and one 1.5” EMT stub, subplate with 4 Keystone port and 4 NEMA 5-20R, gray universal carpet cover
3. Wiremold
   a. “Evolution” 8AT series poke-thru; 8 inch diameter
   b. “Evolution” 6AT series poke-thru; 6 inch diameter
   c. #8ATCPBK; “Evolution” series poke-thru; 8 inch diameter, includes 2 20A duplex receptacles, no mounting plates, 1 5BLH 1/2 gang blank bottom feed, 3 1PTHA 1-gang pass-through housing assembly, 1 575CHA 1/2 gang 3/4” conduit bottom feed, 1 8DIV 8” divider, black painted cover
   d. #8ATCPGY; “Evolution” series poke-thru; 8 inch diameter, includes 2 20A duplex receptacles, no mounting plates, 1 5BLH 1/2 gang blank bottom feed, 3 1PTHA 1-gang pass-through housing assembly, 1 575CHA 1/2 gang 3/4” conduit bottom feed, 1 8DIV 8” divider, gray painted cover
   e. #8ATCPBS; “Evolution” series poke-thru; 8 inch diameter, includes 2 20A duplex receptacles, no mounting plates, 1 5BLH 1/2 gang blank bottom feed, 3 1PTHA 1-gang pass-through housing assembly, 1 575CHA 1/2 gang 3/4” conduit bottom feed, 1 8DIV 8” divider, brass cover
   f. #8ATCPBZ; “Evolution” series poke-thru; 8 inch diameter, includes 2 20A duplex receptacles, no mounting plates, 1 5BLH 1/2 gang blank bottom feed, 3 1PTHA 1-gang pass-through housing assembly, 1 575CHA 1/2 gang 3/4” conduit bottom feed, 1 8DIV 8” divider, bronze cover
   g. #8ATCPNK; “Evolution” series poke-thru; 8 inch diameter, includes 2 20A duplex receptacles, no mounting plates, 1 5BLH 1/2 gang blank bottom feed, 3 1PTHA 1-

gang pass-through housing assembly, 1 575CHA 1/2 gang 3/4” conduit bottom feed, 1 8DIV 8” divider, mickel cover

h. #6ATCPBK; “Evolution” series poke-thru; 6 inch diameter, includes 2 20A duplex receptacles, 1 6ACT8A + 1 6TRAC + 1 6SER mounting plates, 1 5BLH 1/2 gang blank bottom feed, 1 575CHA 1/2 gang 3/4” conduit bottom feed, black painted cover

i. #6ATCPGY; “Evolution” series poke-thru; 6 inch diameter, includes 2 20A duplex receptacles, 1 6ACT8A + 1 6TRAC + 1 6SER mounting plates, 1 5BLH 1/2 gang blank bottom feed, 1 575CHA 1/2 gang 3/4” conduit bottom feed, gray painted cover

j. #6ATCPBS; “Evolution” series poke-thru; 6 inch diameter, includes 2 20A duplex receptacles, 1 6ACT8A + 1 6TRAC + 1 6SER mounting plates, 1 5BLH 1/2 gang blank bottom feed, 1 575CHA 1/2 gang 3/4” conduit bottom feed, brass cover

k. #6ATCPBZ; “Evolution” series poke-thru; 6 inch diameter, includes 2 20A duplex receptacles, 1 6ACT8A + 1 6TRAC + 1 6SER mounting plates, 1 5BLH 1/2 gang blank bottom feed, 1 575CHA 1/2 gang 3/4” conduit bottom feed, bronze cover

l. #6ATCPNK; “Evolution” series poke-thru; 6 inch diameter, includes 2 20A duplex receptacles, 1 6ACT8A + 1 6TRAC + 1 6SER mounting plates, 1 5BLH 1/2 gang blank bottom feed, 1 575CHA 1/2 gang 3/4” conduit bottom feed, nickel cover

m. RC4 series; multi-service flush poke-thru

n. RC3 series; multi-service flush poke-thru

o. AV3 series; multi-service flush poke-thru

p. RC7 series; dual service flush poke-thru

q. AMD8 series; all-communications flush poke-thru

4. Or equal

2.20 MULTI-SERVICE WALL BOXES FOR FLAT PANEL DISPLAYS

A. Application: indoor use as a multi-service (telecommunications, audiovisual, power) outlet box to house wiring, cabling, termination, connectors, and receptacles and serve a flat panel display

B. Listings: Wall boxes shall be listed by a nationally recognized testing laboratory to UL 514A.

C. Fabrication Material: Backbox: Seam welded 14 gauge steel; Cover: 1/16” steel, electro-painted

D. Outlet box shall feature capacity for the following:
1. Power: 1 duplex receptacle, duplex or decora style
2. Telecom/Network: 2 network jacks (refer to section 271513 for jack information)
3. AV: _ positions for AAP (or equivalent) modules
4. Conduit Connections: _ positions for 1.25-inch conduits at top, _ positions for 1.25-inch conduits at bottom, _ positions for 1.25-inch conduits at each side,

E. Manufacturers:
1. FSR
   a. #PWB-100; in-wall multi-service box for flat panel display
   b. #PWB-200; in-wall multi-service box for flat panel display
   c. #PWB-250; in-wall multi-service box for flat panel display
   d. Refer to 274116 for AV accessories
   e. Refer to 271513 for telecom accessories
2. Wiremold
   a. #EFSB2; 2-gang in-wall multi-service box for flat panel disp
   b. #EFSB4; 4-gang in-wall multi-service box for flat panel disp

c. Refer to 274116 for AV accessories
d. Refer to 271513 for telecom accessories

3. Or equal

F. Application: indoor use as a multi-service (telecommunications, audiovisual, power) outlet box to house wiring, cabling, termination, connectors, and receptacles and serve a flat panel display

G. Listings: Wall boxes shall be listed by a nationally recognized testing laboratory to UL 514A.

H. Fabrication Material: Backbox: Seam welded 14 gauge steel; Cover: 1/16” steel, electro-painted

I. Outlet box shall feature capacity for the following:
1. Power: 1 duplex receptacle, duplex or decora style
2. Telecom/Network: 2 network jacks (refer to section 271513 for jack information)
3. AV: _ positions for AAP (or equivalent) modules
4. Conduit Connections: _ positions for 1.25-inch conduits at top, _ positions for 1.25-inch conduits at bottom, _ positions for 1.25-inch conduits at each side,

J. Manufacturers:
1. Chief Manufacturing
a. #PAC521P; in-wall multi-service box for flat panel display
b. #PAC516; in-wall pre-wire box for flat panel display
c. #PAC522; in-wall pre-wire box for flat panel display
d. Refer to 274116 for AV accessories
e. Refer to 271513 for telecom accessories
2. Or equal

2.21 WEATHERPROOF (OUTDOOR) OUTLET BOXES AND COVERS

A. Application: For use outdoors (generally wet, damp, and/or dry locations) as an outlet box, and/or back box of low voltage systems to house wiring, cabling, termination, and connectors; may also house and support components.
1. Outlet boxes shall permit access to conductors for maintenance

B. Outlet boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, for remote control circuits, and for telecommunications circuits in accordance with NEC Article 314.

C. Outlet boxes shall be die cast.

D. Outlet boxes shall come with manufactured threaded openings for connection connections

E. Outlet boxes (box, including conduit connections, plus cover assembly) shall be NEMA 3R rated.

F. Manufacturers:
1. Bell (Hubbell Electrical Products)
a. #5387-0; one-gang box, 4-1/2”H x 2-3/4”W x 2-5/8”D, 3 1” threaded ports
b. #5386-0; one-gang box, 4-1/2”H x 2-3/4”W x 2-5/8”D, 3 3/4” threaded ports
c. #5406-0; one-gang extension, 4-1/2”H x 2-3/4”W x 1”D
d. #5730-0; one-gang in-use cover, vertical, 2-7/8”D closed

e. #5735-0; one-gang in-use cover, vertical, 4-7/8”D closed
f. #5740-0; one-gang in-use cover, horizontal, 2-7/8”D closed
g. #5389-0; two-gang box, 4-1/2”H x 4-1/2”W x 2-5/8”D, 5 1” threaded ports
h. #5387-0; two-gang box, 4-1/2”H x 4-1/2”W x 2-5/8”D, 5 3/4” threaded ports
i. #5407-0; two-gang extension, 4-1/2”H x 4-1/2”W x 1”D
j. #5775-0; two-gang in-use cover, 2-7/8”D closed
k. #5790-0; two-gang in-use cover, 4-7/8”D closed

2. Garvin Industries
a. #WP2G581005; two-gang box, 4-1/2”H x 4-1/2”W x 2-5/8”D, 5 1” threaded ports
b. #WP2G58755; two-gang box, 4-1/2”H x 4-1/2”W x 2-5/8”D, 5 3/4” threaded ports
c. #WPCV2GFI; two-gang cover, 2 GFI openings
d. #WPCV2DUP; two-gang cover, 2 duplex openings
e. #WPCV1DUP; two-gang cover, 1 horizontal duplex opening

3. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of Section 270000.

3.2 EXAMINATION AND PREPARATION

A. Prior to installation, plan routes and locations of pathway systems and coordinate with other trades and building systems (ductwork, plumbing, electrical raceways, wall construction, ceilings, etc.). Pathway systems shall not unnecessarily cross other trade’s work, shall not prevent removal of ceiling tiles or panels, and shall not block access to mechanical or electrical equipment. Provide offsets as required to avoid obstruction of pathway systems with other trades/systems.

B. Prior to installation, examine areas to receive pathways systems to verify conditions are ready for work and to verify conformance with manufacturer and specification tolerances. Notify the Owner’s Representative in writing of conditions that would adversely affect the installation, or subsequent

3.3 INSTALLATION

A. Secure raceway/pathway systems to building structures using approved support methods and components (fasteners, anchors, clamps, hangers, etc) and complaint to the <CEC><NEC<other>.

B. Conduit Systems, including Pull Boxes
1. Run conduit in groups/banks in the most direct route possible, parallel to building lines, and at elevations that avoid unnecessary offsets. Do not route conduit through areas in which flammable material may be stored, or over or adjacent to boilers, incinerators, hot water lines, or steam lines. Completed conduit systems installation shall not encroach into the ceiling height headroom of walkways or doorways.

2. Trapeze Supported Conduit Runs
    a. Support conduit runs using "trapeze" hangers fabricated from construction channel and threaded steel rods anchored to building structures. Fasten conduit to construction channel using standard conduit clamps or equivalent.
    b. Seismically brace trapeze supports compliant to applicable codes.
3. Surface-Mounted Conduit Runs
    a. Single Conduit Runs: Support single conduit runs to building structure using construction channel with approved anchors and hardware or using 2-hole (preferred) or 1-hole conduit straps (or similar support apparatus). Where installed in damp or wet locations, support conduit to building structure using conduit clamp such that clamp backs add space between conduit and mounting substrate.
    b. Multiple Conduit Runs: Support multi-conduit runs to building structure using construction channel with approved anchors and hardware. Select anchors based on installation substrate. Fasten conduit to construction channel using standard conduit clamps or equivalent.
    c. Install vibration control apparatus as required to meet isolation requirements.
4. Install conduit free from dents, bruises or deformations. Remove and replace damaged conduits with new undamaged material.
5. Install metallic conduit so as to not be in contact with other dissimilar metal pipes (e.g., plumbing) to minimize galvanic corrosion.
6. Make bends and offsets using standard conduit bending hand tool and/or machines or use factory fittings. The use of any item not specifically designed for bending conduit is strictly prohibited.
7. When routing conduit within concrete:
    a. Place conduits at a depth as required by the project's structural engineer. In lieu of no direction, place conduits in the middle of the concrete's depth.
    b. Do not place conduits between reinforcing steel and the bottom of floor slabs.
    c. Space conduits a minimum of three conduit diameters apart unless otherwise noted on the drawings.
    d. Avoid crossing conduits (to minimize displacement of concrete). Obtain written approval/detail from structural engineer for crossing and for instances not adhering to general structural details.
    e. Only use compression fittings. Fully wrap fittings with duct tape.
8. For conduits that turn up and protrude from finished concrete, extend conduits 25mm – 75mm (1" to 3") above the surface of the floor, unless conditions require other extension lengths.
9. For rigid and intermediate steel conduit:
    a. Ream conduit smooth after cutting and threading.
    b. Coat field-threaded joints with UL approved conductive type compound to ensure low resistance ground continuity through conduit and to prevent seizing and corrosion.
10. Pull Boxes: Install pull boxes and junction boxes at locations that are accessible. Install pull boxes and junction boxes at locations that are concealed, unless as noted on drawings; pull boxes and junction boxes may be exposed in electrical rooms, utility rooms, storage areas, or when installed in 'open' spaces (such as no ceilings). Adjust locations and installation as coordinated with construction conditions and as required for seismic bracing. Within ceiling space (e.g., above ceiling grid), do not install higher than 1m (~3') above grid.
11. Ream conduit ends cut in the field (non-factory) to eliminate sharp edges, burrs, etc.
12. Clean completed conduits of foreign matter and/or moisture (e.g., pull a bristle mandrel through).
13. Secure pull strings/mule tapes at conduit ends or within boxes to prevent recoiling back into duct.

14. After installation of conduit system and during ongoing general construction, protect conduits and tightly cover/seal open ends.
15. Leave no unused openings in any pull or junction box. Install close-up plugs as required to seal openings.
16. Label each conduit end in a clear manner by designating the location of the other conduit end (i.e. room name, junction box number, etc.). Indicate conduit length on the label.
17. For connections to equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission, use short length (maximum of 6ft) of the FMC or LFMC conduit. For installation in exterior locations, or humidity-laden atmosphere, corrosive atmosphere, water hose or spray wash down operations, and locations subject to seepage or dripping of oil, grease or water, use LFMC. Provide a green ground wire with FMC or LFMC conduit.
18. Terminations, Connections and Joints
    a. Securely connect conduits to boxes, cabinets, wireways, etc., using conduit connectors suitable for the application and one (or two) locknuts and, where required, an insulating bushing or insulated connectors. Torque threaded items to proper tightness.
    b. Where conduits are bonded to ground, securely attach grounding bushings and route bonding jumpers in as short of a path as possible to grounding point.
    c. Where joints and/or connections cannot be made tight, use a bonding jumper to maintain electrical continuity through the connection.
    d. Where terminations are subject to vibration, use a bonding bushing or wedge to maintain electrical continuity through the connection. Where subject to vibration or dampness, use insulating bushings to protect conductors.
    e. Vibration/Movement Isolation: At connections/terminations subject to vibration, movement, misalignment, and/or noise transmission, transition duct bank conduit to a short length (maximum of 2-3 feet) of LFMC. Secure conduit to structure immediately prior to the transition.

C. Innerduct – Textile Type
1. Install innerduct per manufacturer's instructions/guidelines using pulling equipment allowed by the manufacturer. Do not use pulling lubricant when placing textile innerduct. Place textile innerduct using a pulling swivel. Place multiple textile innerducts using a pulling harness (designed specifically for the use) and a swivel.
2. Innerducts shall be continuous from origination room to destination room and/or between pull points. Truncate innerduct at pull points and upon entering telecommunications rooms.

D. Innerduct – Corrugated Type
1. Install innerduct per manufacturer's instructions or guidelines using pulling equipment allowed by the manufacturer. Place innerduct using a pulling swivel. Place multiple innerducts using a pulling harness (designed specifically for the use) and a swivel.
2. Innerducts shall be continuous from origination room to destination room and/or between pull points. Truncate innerduct at pull points and <upon entering telecommunications rooms><just prior to slack storage reels><at termination panel>.
3. When routing through corridors, place innerduct <in primary pathways> <with dedicated supports>. When routing vertically through telecommunications rooms, support innerduct on vertical cable support and fasten innerduct using cable ties; provide cable ties at 24-inch intervals. When routing horizontally through telecommunications rooms, support innerduct on overhead cable support and fasten using cable ties; provide cable ties at 24-inch intervals.

E. Outlet Boxes / Back Boxes
   1. Install boxes plumb and square. Match heights of surrounding outlets (e.g., an adjacent electrical receptacle). Adjust locations and heights as required to suit coordination requirements of construction conditions.
   2. Install boxes flush with walls, ceilings and floors except where exposed work is called for on the drawings, required, or appropriate.
   3. Do not make unused openings in boxes (such as knocking out fabricated knock-outs without using the opening for a conduit connector). Replace boxes containing inadvertent or unused openings.
   4. Framed Walls, both Fire Rated and Non-Rated
      a. Install outlet boxes and covers/raised rings during rough-in such that the finished condition is flush with wall finishes.
      b. Do not install outlet boxes back-to-back (outlet boxes facing opposite sides of a wall). At framed walls not fire rated, install boxes with at least 6" separation. At fire rated framed walls, install boxes with at least 24" and 1 framing stud separation.
      c. Patch/repair openings in wall (plaster, drywall, and/or plasterboard) around boxes and/or raised rings to eliminate visible gaps after outlet gets finished, in accordance with <CEC><NEC> 314.21.
   5. Ceilings
      a. At ceilings, install boxes, supports (such as T-bar support bracket), and cover/ring such that the finished condition is flush with ceiling finishes, except where noted otherwise and where conditions prevent a flush installation
      b. At non-accessible ceilings, install service conduit continuous to an accessible location
   6. Concrete Cast-In-Place Walls and Floors
      a. Set boxes in place within forms (for walls) and casting volume (for floors) such that the finished condition is flush with wall and floor finishes. Ensure proper concrete cover, according to structural requirements.
   7. Masonry Walls
      a. Adjust position of outlet boxes to suit masonry course lines. Coordinate cutting of masonry walls to achieve neat openings for boxes.

F. Wall Boxes for Flat Panel Displays
   1. Install boxes plumb and square. Install boxes and covers/raised rings during rough-in such that the finished condition is flush with wall finishes. Patch openings around covers/raised rings to eliminate visible gaps after outlet gets finished.
   2. Confirm heights of each box. Coordinate with heights of associated services (e.g., electrical receptacle). Adjust locations and heights as required to coordinate with construction conditions.
   3. Do not make unused openings in boxes (such as knocking out fabricated knock-outs without using the opening for a conduit connector). Replace boxes containing inadvertent or unused openings.
   4. Do not install boxes back-to-back in a framed wall (boxes facing opposite sides of a wall), unless noted so on the drawings. At framed walls not fire rated, install boxes with at least 6" separation. At fire rated framed walls, install boxes with at least 24" and 1 framing stud separation.

G. Floor Boxes
   1. Install floor boxes square, plumb, level, and flush with structural floor. Align box with adjacent surfaces.
      a. Tolerance: 1/16"
   2. For floor boxes with combined power and communications circuits, install metal dividers for separation of circuits.

3. Install covers to suit finish conditions. Coordinate floor finishes (such as carpet) with other trades.

H. Poke-Thrus
1. Install poke-thrus flush with structural floor.
2. Install covers to suit finish conditions. Coordinate floor finishes (such as carpet) with other trades.

3.4 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 270000.

B. Comply with system acceptance and certification requirements of Section 270000.

END OF SECTION 27 05 33

SECTION 27 05 36

COMMUNICATIONS BUILDING PATHWAYS – CABLE TRAYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Cable tray systems as pathways within buildings to support low voltage/signal systems

B. Base Bid Work
1. Provide materials and labor, whether explicitly mentioned herein or not, needed for a complete cable tray system to satisfy the requirements of this section and the related drawings. “Complete” shall include supports, seismic bracing, straight sections, fittings, connectors/splices, bonding straps (as required), etc., necessary for a complete installation. This specification lists major equipment but not every accessory, support, fastener, etc., needed to complete the work.
2. Install cable tray systems in accordance with CEC (e.g., Articles 392 and 250), UL listing information, manufacturer’s instructions, and NEMA VE 2, and compliant to local inspections and seismic restraint requirements, NECA’s “Standards of Installation” pertaining to general electrical installation practices, and recognized industry practices. Cable tray systems shall conform to ANSI/TIA-569-B standard and BICSI TDMM guidelines.
3. Supports: Provide supports at each connection point, at fittings, direction transitions, at the end of each run, and at other locations necessary to attain a fully supported and seismically braced cable tray system using a structurally-approved anchoring system and in accordance with NEMA VE 2.
    a. Allowable Support Methods:
        1) Trapeze, consisting of threaded rod, channel/strut or angle iron, and appropriate hardware (anchors, nuts, washers, hold-down clips, etc.)
        2) Single hanger clip (“Flip-Clip”, “trapeze support clip”, other side wire clip)
        3) Cantilever (wall), consisting of wall-mount strut assembly, gusset or triangle assembly, and appropriate hardware (lag bolts, nuts, washers, hold-down clips, etc.)
    b. Disallowable Support Methods:
        1) Center hung, consisting of a single threaded rod and strut or angle iron
4. Seismic Bracing: Provide seismic bracing and restraints to supports and tray system. Seismic bracing shall be approved by a structural engineer licensed in the state of California.
5. Splices: Provide UL classified splice systems by the same manufacturer as the straight sections and fittings.
    a. Wire Mesh Cable Tray Systems Straight Section Splices:
        1) Allowable Splice Methods: washer splice, splice plate, splice bar, wing splice
        2) Disallowable Splice Methods: <list disallowable methods> “Flexmate” splice, “Tab-Loc” strap
            - :
6. Expansion Connections: Provide expansion connectors where required per NEMA VE 1 and/or NEMA VE 2 and per manufacturer’s instructions.

7. Provide radius shields at each bend/corner of “T” type intersections and cross intersections.
8. Vertical Transitions: At vertical transitions of 36 inches (~1 m) or less, provide either a vertical section of tray between both tray levels or a cable dropout on the higher tray section. At vertical transitions of greater than 36 inches (~1 m), provide a section of tray to span between both tray levels.
9. Dropouts:
    a. Provide dropouts as shown on the drawings.
    b. In locations that require 18" wide or 24" wide dropouts, the Engineer will accept combined dropouts, such as one 12" wide dropout with one 6" wide dropout to create an 18" wide dropout, or two 12" wide dropouts to create a 24" wide dropout.
10. Provide blind ends where tray truncations are exposed (i.e., not at a wall).
11. Bonding and Grounding
    a. Provide a bonding strap at connections, expansion joints, sleeves, crossovers, and at other locations where the tray system’s electrical continuity is interrupted and where splices and other accessories are not UL Listed.
    b. Where straight sections or field fittings have been modified during installation such that wires have been removed, provide bonding straps or other accessories to ensure minimum continuous area to satisfy CEC requirements.
    c. Bond cable tray system to approved ground, as per CEC 250.96, using approved connection means.Provide 2 AWG bare copper grounding conductor through entire length of tray. Bond grounding conductor to each component (straight section, fitting, etc.). Connect grounding conductor to approved ground, as per CEC 250.96, using approved connection means.
12. Provide acoustic treatments and/or acoustically rated systems where cable trays or their routs penetrate acoustically rated assemblies/walls. Such treatments and/or systems shall be approved by the project’s acoustician.
13. First-In-Place: Install a single unit of work as described below.
    a. As requested by the Owner, Owner’s Representative, Engineer, or the General Contractor, install a section or sections of cable tray as a first-in-place using the products and installation means and quality intended to be used throughout the building. The installation shall demonstrate cable tray, support means, connections, bonding (as applicable) and seismic bracing (as applicable). Coordinate a meeting for the Owner and Engineer to review the installation. Proceed after obtaining written approval from either the Engineer or the Owner.

C. Related Sections
1. Comply with the Related Sections paragraph of section 270000.
2. Section 260536, “Cable Trays for Electrical Systems”
3. Section 270526, “Communication Bonding”
4. Section 271100, “Communication Rooms”
5. Section _, “Communications Firestopping”

1.2 REFERENCES

A. Comply with the References requirements of section 270000.

B. In additional to those codes, standards, etc., listed in 270000, products (including fabrication process) and installation shall comply with the latest edition of the following applicable specifications and standards:
1. ASTM International
    a. ASTM A 123, “Specification for Zinc (Hot Galvanized) Coatings on Iron and Steel”

b. ASTM A 510, “Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel”
c. ASTM A 580, “Standard Specification for Stainless Steel Wire”
d. ASTM A525, “General Requirements for Steel Sheet, Zinc-Coated Galvanized by the Hot-Dip Process”
e. ASTM A 580, “Standard Specification for Stainless Steel Wire”
f. ASTM A591, “Specifications for Electrodepositing Coatings of Zinc on steel wire or sheets”
g. ASTM A 641, “Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire”
h. ASTM A 653, “Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process”
i. ASTM B 633, “Specification for Electrodeposited Coatings of Zinc on Iron and Steel”
j. ASTM D 769, “Standard Specification for Black Oxide Coatings”
k. ASTM D3451, “Standard Guide for Testing Coating Powders and Powder Coatings”

2. National Electrical Manufacturer Association (NEMA)
   a. NEMA VE 1, “Metal Cable Tray Systems”
   b. NEMA VE 2, “Metal Cable Tray Installation Guidelines”
3. National Electrical Contractors Association (NECA)
   a. NECA/NEMA 105, “Recommended Practice for Installing Cable Trays”
4. National Fire Protection Agency (NFPA)
   a. NFPA 70B, “Recommended Practice for Electrical Equipment Maintenance”
   b. NFPA 70E, “Standard for Electrical Safety In The Workplace”
5. Underwriters Laboratories (UL)
   a. UL 467, “Grounding and Bonding Equipment”
6. Manufacturer’s guidelines and installation instructions

1.3 DEFINITIONS

A. Definitions of section 270000 apply to this Section.

B. In addition to those Definitions of 270000, the following list of terms as used in this Section defined as follows:
1. “AHJ”: Authority Having Jurisdiction; “the organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure” (per NFPA)
2. “Cable Tray” and “Cable Tray System”: a unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways
3. “CEC”: California Electrical Code (CCR Title 24 Part 3)
4. “LEED”: Leadership in Energy and Environmental Design
5. “CEC”: California Electrical Code (NFPA 70)
6. “NEMA”: National Electrical Manufacturers Association
7. “NFPA”: National Fire Protection Agency
8. “Wire Mesh Cable Tray”: a cable support and management system fabricated of continuous, rigid, welded steel wire mesh; available in many sizes with attachment hardware suiting multiple installation methods; falls under NFPA 70’s definition as cable tray.

1.4 SYSTEM DESCRIPTION

A. Cable tray systems shall be electrically continuous maintaining minimum metal area requirements per CEC Table 392.7 (for use as an equipment grounding conductor).

B. Bend Radius: Completed cable tray systems shall have a 12", minimum, radius, e.g., at fittings (factory and field-fabricated) and changes of direction.

C. Cable tray supports (e.g., trapeze) shall carry a concentrated load of at least 200 pounds per anchorage point.

D. Seismic Bracing: Cable tray systems shall include both lateral and longitudinal seismic bracing.

E. Clearances (minimum):
   1. Top access clearance: Refer to the drawings; if not explicitly stated or shown, then the default shall be 12 inches (300 mm), minimum.
   2. Side access clearance: Refer to the drawings; if not explicitly stated or shown, then the default shall be 12 inches (300 mm), minimum.
   3. Between cable tray and fluorescent light fixtures, or other EMI sources: Refer to the drawings; if not explicitly stated or shown, then the default shall be 6 inches (150 mm), minimum.
   4. Between cable tray and any motor or transformer: Refer to the drawings; if not explicitly stated or shown, then the default shall be 48 inches (1,220mm), minimum.
   5. Between cable tray and any flue, hot water, steam line or other non-insulated heat sources: Refer to the drawings; if not explicitly stated or shown, then the default shall be 12 inches (300 mm), minimum.

F. Penetrations
   1. When penetrating concrete walls (including shear walls) and/or floors, scan the area to be penetrated and core openings using methods approved by the structural engineer and by the AHJ. Obtain written approval for locations and means when not using methods included in the contract documents.
   2. At fire partitions or smoke partitions, truncate cable trays and penetrate partitions using UL Classified systems in accordance with ASTM E814 (UL1479) that maintain the partition's rating(s). Provide labels at both sides of the penetration. Refer to drawings for approved systems per application.
   3. At acoustically rated partitions:
      a. Penetrations of partitions and construction assemblies shall meet the project's acoustical requirements for construction assemblies and penetrations.
      b. Check each penetration instance against the acoustical requirements to minimize reduction(s) in the composite sound isolation performance of the penetration.
      c. Provide acoustical treatments as specified in the project's documentation.

1.5 SUBMITTALS

A. General: Conform to Submittal requirements as described in section 270000.

B. Submittal Requirements Prior to the Start of Construction:
   1. Product Data: Submit product data showing manufacturers, part numbers, dimensions, fabrication materials, fabrication details, finishes, capacities, and accessories.
   2. Acoustic Systems: Submit acoustic treatments/systems including testing data and/or judgements.

3. Shop Drawings: Submit shop drawings consisting of the following:
    a. Cable tray layout/routes, supports locations, support details
    b. Highlight proposed changes to pathways (routes, types, sizes, etc.) compared to the contract documents
    c. Clearance variations and/or requests for exceptions
    d. Load calculations for supports
    e. Seismic bracing details (also see “Seismic Calculations” below)
    f. Instances of penetrations through fire and smoke rated barriers, including calling out firestopping type/UL System, size, quantity, and other relevant information
    g. Instances of seismic joints, including method and configuration to allowing independent movement, and other relevant information.
4. Seismic Calculations: Submit seismic calculations for support systems in conformance section 270000. Structural Calculations shall be prepared and signed by a California Registered Structural Engineer. If used, specify proof loads for drilled-in anchors.
5. LEED Information: Submit Mill Certification of recycled content.

C. Submittal Requirements at Close Out:
1. As-Built Drawings, showing the routes, dimensions, types, sizes, quantities, etc. (minimum)
2. O&M Manual, including as-builts, parts list, repair information, and maintenance requirements

D. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in section 270000.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of section 270000.

B. Cable tray materials and parts shall be UL Listed and Labeled, and shall comply with CEC Article 392 and with NEMA VE 1/CSA C22.2 No. 126.1 “Metal Cable Tray Systems” for materials, sizes, and configurations.
1. The terms “Listed” and "Labeled" shall mean as defined in CEC, Article 100.
2. Listing and Labeling Agency Qualifications: a "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

C. Cable tray installation shall comply with CEC Articles 392 (for materials and installation) and 250.96 (for bonding) and with NEMA VE2.

D. Assembled cable tray systems shall be UL Classified as an equipment ground conductor.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of section 270000.

1.8 WARRANTY

A. Comply with Warranty requirements of section 270000.

PART 2 - PRODUCTS

2.1 CABLE TRAY – WIRE MESH TYPE

A. Application: Suitable for the support and management of communications cables, either overhead or mounted vertically on a wall.

B. Listing: Cable tray system (straight sections, fittings, splice kits, etc.) shall be UL-Classified as a grounding conductor. Cable tray shall be listed by a nationally recognized testing laboratory and shall bear the UL label. Markings shall be permanent.

C. Material: Straight sections shall be fabricated from high strength steel wires meeting the minimum mechanical properties of ASTM A510 and formed into a standard 2-inch by 4-inch wire mesh pattern with intersecting wires welded together. Wire ends along sides (flanges) shall be rounded during manufacturing for safety of cables and installers. Longitudinal wires shall be straight (with no bends).

D. Finish – straight sections: Straight sections shall be electro-plated zinc, in accordance with ASTM B633, Type II SC1 (or SC2).>

E. Splicing assemblies shall be the bolted-type using serrated flange locknuts. Hardware shall have SC2 yellow zinc chromate finish, in accordance with ASTM B633, or can be AISI Type 304 Stainless Steel.

F. Size: Refer to Drawings for sizes.

G. Manufacturers, or equal:
   1. B-Line (Eaton) “Flextray” series cable tray
   2. Chatsworth Products Inc “OnTrac” “Round” series cable tray
   3. WBT cable tray

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of section 270000.

B. Install cable tray systems in accordance with manufacturers’ instructions, with NEMA VE 2 and with recognized industry practices. Install cable tray systems compliant to requirements of NEC, applicable portions of NFPA 70B, and to NECA's “Standards of Installation” pertaining to general electrical installation practices.

3.2 PREPARATION

A. Routes shown on the drawings are diagrammatic in nature. Plan routes and locations of pathway systems, and coordinate the installation (concrete drilling, anchors, supports, heights, clearances, access to the trays, interface with sleeves, etc.) with other trades/systems (ductwork, plumbing, electrical raceways, wall construction, ceilings, etc.). Field verify the planned route prior to installation.

B. Pathway systems shall not unnecessarily cross other trade's work, shall not prevent removal of ceiling tiles or panels, and shall not block access to mechanical or electrical equipment. Offset trays as required to avoid obstruction of pathway systems with other trades.

C. Prior to installation, examine areas to receive pathways systems to verify conditions are ready for work and to verify conformance with manufacturer and specification tolerances. Notify the Owner's Representative in writing of conditions that would adversely affect the installation, or subsequent utilization, of the system. Proceed with installation when unsatisfactory conditions are corrected.

3.3 INSTALLATION

A. In general, install cable trays parallel or at right angles to the centerlines of columns and beams.

B. Access and Clearances:
   1. Ensure clearance and access requirements to cable tray – above, below, and side, as shown on the drawings – are met. Coordinate with other trades to avoid other building infrastructure encroaching on access/clearance.
   2. Ensure no other trades/building systems conflict with cable tray systems and clearances. Other building infrastructure, such as columns, pipes, valves, etc., shall not route inside or through cable tray. Either relocate/alter other building infrastructure (preferred) or, if other building infrastructure cannot be altered, adjust the cable tray route to avoid conflicts other building infrastructure.
   3. Under no circumstance shall cable tray block or inhibit access to fire smoke dampers or other code-required access. All such conditions will require corrective actions be taken. Adherence to this requirement will be strictly enforced.

C. Provide supports according to applicable codes, NEMA VE2, and approved shop drawings. Do not share supports with ductwork, piping, or other equipment hangers. Attach supports to the exterior of the cable tray. Do not install brackets, rods, etc., through the inside of the cable tray.

D. Do not install more than one splice or junction between supports.

E. Fabricate fittings (tee, cross, reducers, and 90-degree turns) in the field according to the manufacturer's instructions and to ensure the pathway system remains UL listed. Bends shall have a minimum of a 12-inch bend radius.

F. At transitions to and/or interface with conduits and/or sleeves, align ends of cable trays directly underneath the conduits/sleeves or within the allowable offset ranges as shown in the drawings. Refer to the drawings for additional information.

G. At rated partitions, either transition to an approved acoustically rated sleeve or penetrate the partition using an approved acoustically rated system.

H. At building seismic joints, provide seismic joint in cable tray system according to approved shop drawings.

I. Remove burrs and sharp edges.

J. Bonding
   1. Bond the cable tray system per "[Summary] Base Bid Work" requirements.
   2. If splice kits are not UL Listed, then provide bonding jumpers at each splice/junction.
   3. Bond completed cable tray systems to approved ground according to applicable codes.

4. At connection points:
    a. Thoroughly clean connection surfaces prior to attaching connection/termination components.
    b. At painted surfaces, remove paint to completely expose metal – enough for the connector to make 100% contact by area with the surface.
    c. Apply antioxidant joint compound to the surface prior to receiving connection/termination components.
    d. Attach connection/termination components using hardware sets appropriate for the connector and receiving surface. Tighten hardware sets.
        1) For lugs at holes, use appropriately sized bolt, flat washer, Belleville or split washer, and nut.
        2) For lugs at studs, use appropriately sized flat washer, Belleville or split washer, and nut.
    e. Connections shall be visible, accessible and verifiable.

K. Protection: Protect installed system until completion of project. Touch-up, repair or replace damaged products before punch walk.

3.4 TESTING

A. Test cable tray systems for electrical continuity throughout and its bonding connection to approved ground point(s).

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the work of this section compliant to the requirements of section 270000.

B. Comply with system acceptance and certification requirements of section 270000.

END OF SECTION 27 05 36

SECTION 27 08 11

COMMUNICATIONS TWISTED PAIR TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Testing of communications Backbone and Horizontal twisted pair cabling subsystem.

B. Base Bid Work
1. Testing of a completed communication infrastructure cabling system, which includes:
a. Submittals
b. Testing of the twisted pair cabling as follows:

Table 270811-1.1: Tests For UTP Cabling

Subsystem	Type	Test	Configuration	Notes
Backbone	ISP/Riser	*see “Notes”	-	Wire map, length
Horizontal	CAT6A	Category 6A	Permanent Link Channel	per TIA-568

c. Record Documents, including test results.

C. Work Provided Under Other Sections
1. Backbone twisted pair cabling
2. Horizontal twisted pair cabling

D. Related Sections
1. Comply with the Related Sections paragraph of section 270000.
2. Section 271313, “Communication Backbone ISP Twisted Pair Cabling”
3. Section 271513, “Communication Horizontal Twisted Pair Cabling”

1.2 REFERENCES

A. Comply with the References requirements of section 270000.

B. In addition to the References of section 270000, the following references apply to this specification:
1. ANSI/TIA-1152, “Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling”

1.3 DEFINITIONS

A. Refer to Definitions of section 270000, section 271313, and section 271513.

B. In addition to those Definitions of section 270000, the following list of terms as used in this specification defined as follows:
1. “CAT3”: Shall mean Category 3 cabling (per TIA-568)
2. “CAT6A”: Shall mean Augmented Category 6 cabling (per TIA-568)

3. “Channel”: Shall mean a testing configuration which includes the Permanent Link and the line cord (at the workstation), the equipment cord, and, if a full crossconnection is implemented, a patch cord and the crossconnect termination/connecting apparatus.
4. “Connect”: Shall mean install all required patch cords, equipment cords, cross-connect wire, etc. to complete an electrical or optical circuit.
5. “Cord”: Shall mean a length of cordage having connectors at each end. The term “Cord” is synonymous with the term “Jumper” and “Lead”.
6. “Permanent Link”: Shall mean the ‘permanent’ portion of the Horizontal cabling to each outlet with the test cords de-embedded from the measurements; this includes cable, consolidation point (if used), termination/connecting apparatus in the IDF and the connector at the outlet.
7. “System Cord”: Shall mean the cord used in the operating transmission circuit.
8. “Test Cord”: Shall mean the cord certified for use in testing, as described in this section.

1.4 SYSTEM DESCRIPTION

A. Refer to section 270000, section 271313, and section 271513 for addition system description information.

1.5 SUBMITTALS

A. Comply with the Submittal requirements of section 270000.

B. Submittal Requirements prior to the Start of Testing
1. Testing Procedures Submittal: Submit as a PDF file the step-by-step procedures that the field technicians will follow during testing.
2. Product/Equipment Submittal: Submit as a PDF file cutsheets of testing equipment and applicable accessories to be used. As applicable, note software/firmware versions and last factory calibrations.
3. Schedule Submittal: Submit as a PDF file a proposed schedule of work. This schedule may be combined with the schedule developed for the work of Related Sections (listed above).

C. Submittal Requirements at Closeout
1. Test Reports and Measurement Data: After completing testing of cabling and before final closeout, submit test reports and measurement data. This report may be combined with the test reports of section 270821.
    a. Test Reports Content and Organization
        1) Cover Page, with the following information:
            a) Client/Owner Name
            b) Project Name and Address
            c) Report Name (e.g., “Test Reports for Horizontal Cabling System”)
            d) Date of Submittal – date format: **Month Day, Year** (e.g., “January 1, 2018”)
            e) Testing Company Name
        2) Table of Contents
        3) Warranty Certificate: include a certificate stating that the testing company warrants the validity of the test reports; this may be a letter on company letterhead or a traditional certificate format.
        4) Test Reports: report per link showing tested parameters and results from prescribed performance levels (e.g., CAT6A PASS); organize test reports by

backbone cabling/horizontal cabling, by building, by floor, and by telecom room.

b. Test Reports Format
   1) Submit test reports as a PDF file. The Table of Contents shall have links to organized sections.

c. Measurement Data
   1) Submit native measurement data format (for example, an *.FLW file from a Fluke tester); if native data format is not possible to submit, then submit measurement data as an exported Microsoft Excel compatible format. Include 'Viewer' software necessary to view, sort, filter, and print individual and summary test results from the native data format.

d. Transmittal
   1) The preferred method of transmitting closeout submittals is via a cloud-based file transfer platform (such as Dropbox or similar).
   2) If by data storage disc (not preferred), 'burn' the test reports and measurement data onto one storage disc (e.g., CD-ROM or DVD). Clearly label the disc with the "Cover Page" information described above.

1.6 QUALITY ASSURANCE

A. Comply with the Quality Assurance requirements of section 270000.

B. Under no circumstances shall any cable's and/or conductor's test results be substituted for another's. If an instance of falsification is confirmed, the Contractor is liable for a complete retest of the cabling system at no additional cost to the Owner. This includes the retaining the services of a neutral party to observe all retesting.

1.7 WARRANTY

A. Warrant the validity of the test results.

PART 2 - PRODUCTS

2.1 CATEGORY 6A HORIZONTAL CABLE TESTER

A. Certification: Test equipment and accessories (adapters, cords, etc.) shall be independently verified to and compliant with ANSI/TIA-1152-A Level 2G field tester accuracy requirements to 2000 MHz.

B. Test Standards (minimum): TIA-568 Category 6A under a permanent link, MPTL, and channel configuration; IEEE 802.3 100Base-TX, 1000Base-T, and 10Base-T; screen continuity along path of cabling;

C. Equipment, or equal:
   1. Fluke Networks
      a. #DSX-5000 or DSX-8000 (or DSX2-8000); "CableAnalyzer" test kit (main unit, remote unit, CAT6A permanent link adapters, CAT6A channel adapters, CAT6A patch cord adapters, accessories), loaded with the latest firmware version.
      b. "LinkWare" PC management software, latest version of and documentation software

PART 3 - EXECUTION

3.1 SCHEDULING

A. Prepare a testing schedule based on the construction schedule developed in sections 271313 and 271513 for the testing activities. Update testing schedule when changes in the cabling schedules occur.

3.2 FIELD QUALITY CONTROL

A. Calibrate test sets and associated equipment per the manufacturers printed instructions at the beginning of each day's testing and after each battery charge. Fully charge the test sets prior to each day's testing to ensure proper operation.

B. Ensure test equipment and test cords are clean and undamaged during testing activities. At the Engineer's discretion, halt testing activity and clean testing equipment, test cords, and related apparatus.

3.3 BACKBONE TWISTED PAIR CABLING TESTING REQUIREMENTS AND PROCEDURES

A. Precautions
1. Adhere to the equipment manufacturer's instructions during all testing.
2. Prior to any testing activity or any measurements taken, ensure the test equipment is at room temperature – approximately 70 degrees F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
3. Fully charge power sources before each day's testing activity

B. Testing Requirements
1. Test backbone multipair cabling per "Base Bid Requirements" in Part 1 of this Section.
2. The installation will be accepted when testing has indicated availability of 100% terminated pairs.

C. Testing Procedures
1. Test continuity and wire map for all pairs.
2. Test length for 2% of pairs of each cable. Pairs shall be from different 25-pair binder groups.

D. Acceptable Test Result Measurements
1. Overall:
   a. Links which report a Fail, Fail* or Pass* for any of the individual tests shall result in an overall link Fail. All individual test results must result in a Pass to achieve an overall Pass.
   b. Any reconfiguration of a link components required as a result of a test Fail, must be re-tested for conformance.
   c. Remove and replace any cabling links failing to meet the criteria described in this specification, at no cost to the Owner, with cables that prove, in testing, to meet the minimum requirements.
2. Length
3. Wire Map: Provide continuous cable link and terminate all pairs correctly at both ends. No exceptions accepted.

4. Attenuation: The acceptable attenuation measurements for any CAT3 cabling link is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3 and as adjusted to length measurement.
5. Worst Pair-to-Pair Near End CrossTalk (NEXT) Loss: The acceptable worst pair-to-pair NEXT loss no greater than that listed in ANSI/EIA-568-C.2, 6.3 for CAT3 cabling.

3.4 HORIZONTAL CATEGORY 6A TESTING PROCEDURES

A. Precautions
1. Adhere to the equipment manufacturer's instructions during all testing.
2. Prior to any testing activity or any measurements taken, ensure the test equipment is at room temperature – approximately 70 degrees F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
3. Fully charge power sources before each day's testing activity

B. Test Equipment Set Up
1. Set up the tester to perform a full CAT6A test, as a Permanent Link Channel configuration.
2. If the tester has cable-specific test parameters pre-loaded, set up the tester as product-specific setting. If not, set as generic CAT6A.
3. Set the tester to save the full test results (all test points, graphs, etc.).
4. Save the test results with the associated cable link identifier.
5. Calibrate the test set per the manufacturer's instructions.

C. Acceptable Test Result Measurements
1. Overall Test Results:
   a. The Owner shall accept only individual test results that result in a Pass.
   b. Links which report a Fail, Fail* or Pass* for any of the individual tests shall result in an overall link Fail.
   c. Any reconfiguration of link components required as a result of a test Fail, must be re-tested for conformance.
   d. Remove and replace any cabling links failing to meet the criteria described in this specification, at no cost to the Owner, with cables that prove, in testing, to meet the minimum requirements.
2. Wire Map: Correctly terminate all pairs of the cabling link at both ends. Provide only continuous pairs. No exceptions.
3. Length: Ninety-four meters is the maximum acceptable electrical length measurements for any cabling link measured under a Permanent Link configuration, including test cords.
4. Insertion Loss: The acceptable insertion loss measurements for any CAT6A cabling link is that which is no greater than that listed in TIA-568.1-D.
5. Worst Pair-to-Pair Near End CrossTalk (NEXT) Loss: The acceptable worst pair-to-pair NEXT loss for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.
6. Power Sum NEXT Loss: The acceptable power sum PS-NEXT loss for any CAT6A cable is that which is no greater than that as listed in TIA-568.1-D.
7. Worst Pair-to-Pair ELFEXT and FEXT Loss: The acceptable worst pair-to-pair ELFEXT and loss for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.
8. Power Sum ELFEXT and FEXT Loss: The acceptable PS-ELFEXT and loss for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.
9. Alien Near End CrossTalk (ANEXT) Loss: The acceptable ANEXT loss for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.

10. Alien Far End CrossTalk (AFEXT) Loss: The acceptable AFEXT loss for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.
11. Return Loss: The acceptable return loss measurements for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.
12. Propagation Delay and Delay Skew: The acceptable propagation delay and delay skew measurements for any CAT6A cable is that which is no greater than that listed in TIA-568.1-D.

3.5 TEST REPORTS

A. Permanently record measurements and test results.

B. Submit test results to the Engineer after testing for approval. The Engineer will check these test reports for a format acceptable to the Owner, or Owner's Representative. Each cabling link test record shall contain the following information:
   1. Project name and address
   2. Testing Company's name and Operator's name
   3. Date of measurement/test
   4. Test equipment, including the following:
      a. Manufacturer, model, and serial number
      b. Date and time of last calibration
   5. Cable identification and (as applicable) pair identification
   6. Overall test result

C. Cable and pair identifiers of the test reports shall match the identifiers as labeled in the field – i.e., use the ID on the cable label/termination label in the test reports.

END OF SECTION 27 08 11

SECTION 27 08 21

COMMUNICATIONS FIBER OPTIC TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Testing of telecommunications fiber optic cabling.

B. Scope Of Work of this Section
1. Pre-Testing Submittals (also see “Submittals” for more details)
2. Inspection of completed fiber optic passive link segment(s) per IEC 61300-3-35.
3. Testing of completed fiber optic passive link segment(s) per the following table (also see “Part 3” for elaboration of testing requirements), according to ANSI/TIA-568-C.0 Annex E:

Subsystem	Type	Test	Direction	Wavelength
Backbone	Multimode	Tier 1, Method B (per TIA-526-14-B)	Both^	850nm and 1300nm
Backbone	Singlemode	Tier 1, Method A.1 (per TIA-526-7)	Both^	1310nm and 1550nm

4. Pre-Acceptance Submittals

C. Work Provided Under Other Sections
1. Fiber optic cabling and patching

D. Related Sections
1. Comply with the Related Sections paragraph of Section 270000.
2. Section 271323, “Communication Backbone ISP Fiber Optic Cabling”

1.2 REFERENCES

A. Comply with the References requirements of Section 270000.

B. In addition, the following standards are referenced to this Section:
1. American National Standards Institute (ANSI) Z136.2, “American National Standard for the safe use of optical fiber communication systems utilizing laser diode and LED sources”
2. ANSI/TIA-455-50B, “Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements”
3. TIA-455-77, “Procedures To Qualify A Higher-Order Mode Filter For Measurements On Singlemode Fibers”
4. TIA-455-78A, “Spectral-Attenuation Cutback Measurement for Singlemode Optical Fibers”
5. EIA-455-95, “Absolute Optical Power Test for Optical Fibers and Cables”
6. EIA-455-171A, “Attenuation By Substitution Measurement – For Short-Length Multimode Graded-Index And Single-Mode Optical Fiber Cable Assemblies”
7. TIA-526-7, “Measurement of Optical Power Loss of Installed Singlemode Fiber Cable Plant”
8. TIA-526-14-B (TIA-455-526-14B), “Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant”

9. TIA-TSB-4979, “Practical Considerations for Implementation of Multimode Launch Conditions in the Field”
10. ISO/IEC 14763-3, “Testing of Optical Fibre Cabling”
11. IEC 6100-3-35 (end faces)
12. IEC 61300-3-35, “Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-35: Examinations and measurements – Fibre optic connector endface visual and automated inspection”
13. IEC 61280-4-1
14. IEC 61280-4-2, “Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant”
15. BICSI Telecommunication Distribution Methods Manual (TDMM)

1.3 DEFINITIONS

A. Refer to Definitions of sections 270000, 271323. The definitions of these sections apply to this section.

B. In addition to those definitions in referenced sections, the following list of terms as used in this specification defined as follows:
1. “Adapter” (associated with fiber connectivity): a connecting device that joins 2 fiber connectors, either like or unlike
2. “Approved cleaning equipment”: includes dry “one-click” probe type cleaners and/or other approved cleaning apparatus; also see “Cleaning Apparatus under Pat 2
3. “Connect”: install all required test cords, patch cords, system cords, etc. to complete an optical circuit
4. “Cord”: a length of cordage (simplex, duplex, or ribbon) having connectors at each end; the term “Cord” is synonymous with the term “Jumper”
5. “Defect”: detectable (via microscope) non-linear features on the end face of a fiber including particulates, debris, pits, chips, edge chipping, etc. as defined in 3.1 of IEC 61300-3-35 Edition 1
6. “High Resolution” (microscope): as defined in 4.4.3 of IEC 61300-3-35 Edition 1
7. “Jumper”: see “Cord”
8. “Low Resolution” (microscope): as defined in 4.4.2 of IEC 61300-3-35 Edition 1
9. “OLTS”: Optical Loss Test Set
10. “Scratch”: detectable (via microscope) permanent linear surface features on the end face of a fiber as defined in 3.1 of IEC 61300-3-35 Edition 1
11. “Segment”: cabling (cable, splices, couplings, splitters, connectors, etc.) between termination points / 2 endpoints or between points of access to the conductors within the cabling sheath, including the termination apparatus/components
12. “System Cord”: the cord used in the operating electrical or optical circuit
13. “Test Record”: a record (electronic and/or printed) of a the measured performance of a conductor against a standardized set of metrics
14. “Test Report”: a report containing a set of test records meeting a defined scope
15. “Tier 1”: testing of installed fiber optic cabling for loss (optical link power loss) with an OLTS, and verifying the cabling length and polarity – also refer to ANSI/TIA-568-C.0 Annex E
16. “Test Cord”: the cord certified for use in testing, and meeting the requirements of this section

1.4 SYSTEM DESCRIPTION

A. Refer to section 271323for description of cabling systems.

1.5 SUBMITTALS

A. Comply with the Submittal requirements of section 270000.

B. Pre-Testing Submittal Requirements: Prior to the start of testing, submit the following:
   1. Product Data, submitted at least 8 weeks in advance the start of field measurements
   2. Testing Procedures, submitted at least 8 weeks in advance the start of field measurements
   3. Pre-Testing Loss Calculations, submitted at least 4 weeks in advance the start of field measurements
   4. Testing Schedule, submitted at least 4 weeks in advance the start of field measurements

C. Pre-Acceptance Submittal Requirements: Prior to owner's acceptance, submit the following:
   1. Test Reports: Submit test reports in a format acceptable to the Owner or Engineer. Submit one electronic copy and one printed copy of test reports. This may be combined with the reports of Section 270811.
   2. Warranty Certificate: Submit warranty certificate in a format acceptable to the <Owner> <Engineer>.

D. Submittal: Product Data
   1. Testing equipment ('mainframes', modules, remotes, etc.) including the following information (minimum):
      a. Manufacturer and model number
      b. Serial number
      c. Date of last factory calibration
      d. Software/firmware versions (as applicable)

E. Submittal: Testing Procedures
   1. Describe step-by-step procedures the technicians will use in the field during actual testing – standards-based test methods, test equipment including the test cords and conditioners used, equipment configuration, how the reference gets established, etc. – something to which the engineer could compare the testing witnessing (observe testing technicians actually following these written step-by-step procedures).

F. Submittal: Pre-Testing Loss Calculations
   1. Calculate the loss of each segment (not necessarily each fiber strand). The cable length may be based on the footage markings printed on the cable jacket. Include a brief description of each segment (such as endpoints).

G. Submittal: Schedule
   1. Consists of proposed schedule of work (this schedule may be combined with the schedule developed for Division 27)

H. Submittal: Test Reports

1. Each test record shall include information per test as noted following:

CONTENT	LOSS – MMF	LOSS – SMF	CHARACTERIZATON
Owner/Project Name and Address	X	X	X
Contractor (Company) Name and Technician (test equipment operator) name	X	X	X
Date of Test	X	X	X
Test Equipment, including Serial Numbers (must match pre-testing submittal)	X	X	X
Test Procedure	X (e.g., OFSTP-14A, Method B)	X (e.g., OFSTP-7, Method A.2)	X
Test Cords – Type and Length	X	X	–
Test Cords – Measured Loss	X	X	–
Launch Fiber – Type and Length	–	–	X
Fiber/Strand Identifier and Fiber Type (e.g., “OM3”)	X	X	X
Test Equipment Set Up Parameters: wavelength, pulse width, refractive index, event threshold	–	–	X
End Locations and Measurement Direction	X	X	X
Wavelength	X	X	X
Reference Power Level	X	X	–
Optical Loss Measurement / Overall Loss	X	X	X
Characterization Trace	–	–	X
Fiber Length	X	X	X

2. Cable and fiber identifiers of the test reports shall match the identifiers as labeled in the field – i.e., the ID stored with the test result shall be the same ID as on the cable label/fiber port label.
3. Test Report Format – Electronic Submittal of Tier 1 Testing:
   a. Submit test report files as native data format (for example, an *.FLW file from a Fluke tester) and printed to PDF format assembled into a single file. Organize reports by backbone cabling, by floor, and by IDF.
   b. For the native data format files, include the ‘Viewer’ or ‘Reader’ software necessary to view, sort, filter, and print individual and summary test results.
   c. Organize the test records by (in this hierarchy): backbone cabling , by floor, by IDF, by sheath and by strand.
4. Test Report Format – Printed Submittal of Tier 1 Optical Loss Testing:
   a. Submit printed test reports, on 8.5”x 11” paper, color, one cabling link per page
   b. Assemble prints into a 3-ring binder
   c. Include a Table Of Contents at the beginning that lists the contents
   d. Organize the test records by (in this hierarchy): backbone cabling, by floor, by IDF, by sheath and by strand. Include tabbed separators for improved navigation through the manual. Per tabbed section, sort records in ascending cable ID order.

I. Submittal: Warranty Certificate
   1. Submit one printed copy of warranty certificate warrantying the accuracy and validity of the test reports.

1.6 QUALITY ASSURANCE

A. Comply with the Quality Assurance requirements of section 270000.

B. Test equipment shall be fully functional and in proper working order (not broken adapters, connectors, buttons, battery cover, etc.). Test equipment shall have loaded the latest firmware/operating software.

C. Calibration: Test equipment shall be factory calibrated within the manufacturer's published calibration period. The manufacturer, where applicable, shall calibrate test equipment against National Institute of Standards and Technology (NIST) standards.

D. Technician Training: Technicians that operate test equipment shall have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR, and shall have obtained a certificate as proof thereof. Training may have been conducted by any of the following:
   1. Manufacturer of the test equipment used for the field certification
   2. Manufacturer of the fiber optic cable system
   3. Training organizations (such as BICSI)

E. Cleaning: Throughout testing, clean connector end faces and adapter alignment sleeves using an approved cleaner and cleaning method – also refer to "Field Quality Control" in Part 3.

1.7 WARRANTY

A. Warrant the validity of the test results and that no test measurements have been falsified. Issue such warranty in writing. Under no circumstances shall any cable's and/or optical conductor's test results be substituted for another's. If an instance of falsification is confirmed, the Contractor will be liable for a complete retest of the cabling system at no additional cost to the Owner. This includes the retaining the services of a neutral party to observe all retesting.

PART 2 - PRODUCTS

2.1 DIGITAL INSPECTION MICROSCOPE

A. Digital inspection microscope shall be suitable for inspecting and certifying connector end faces. The microscope shall be a digital video camera type with probe tips (to permit inspection through adapters) and shall be capable of storing the end face images for inclusion in the test reports.

B. Microscope shall be compatible with IEC 61300-3-35, particularly 4.2 "Method B: video microscopy".

C. Microscope shall have adapters that match/are compatible with the connector(s) being inspected.

D. Magnification: low resolution or high resolution

E. Manufacturer, or equal:
   1. AFL
      a. “FOCIS PRO”; fiber optic connector inspection system, including a #DFS1 digital inspection microscope and a #DFD1 touchscreen tablet preloaded with ‘SimpleView PRO’ fiber inspection software
      b. #DFS1; ‘FiberScope’ digital inspection microscope with USB connection used in conjunction with ‘SimpleView PRO’ fiber inspection software on a laptop or with Link WiFi unit and FOCUS MOBILE app loaded on an iPhone, iPad, or Android mobile device
   2. Corning
      a. #VIPROBE-DUAL; video inspection probe (for use with OV-1000 V2 OTDR mainframe)
   3. Fluke Networks
      a. #FI-7000; ‘FiberInspector Pro’ series digital inspection microscope

2.2 OPTICAL LOSS TEST SET (OLTS) – SINGLE STRAND TESTING

A. OLTS can be an integrated set or separate light source and power meter. The test equipment shall, either as an integrated set or as separates, meet the following specifications/requirements.

B. Multimode Light Source: The light source used for testing multimode fibers shall meet the requirements of ANSI/TIA-526-14-B, 3.1. Additional requirements:
   1. Type: LED
   2. Central wavelengths: 850nm ±30 nm, 1300nm ±20 nm
   3. Output stability: +/- 0.40 dB from 0 to 50 degrees C
   4. Long term output stability: +/- 0.10 dB at 25 degrees C
   5. Output power: –20 dBm, minimum
   6. Encircled Flux: light source shall meet the encircled flux launch requirements of TIA-455-526-14B, ISO/IEC 14763-3, and IEC 611280-4-1 for 50/125 um at the source’s optical connector.

C. Singlemode Light Source: The light source used for testing singlemode fibers shall meet the requirements of TIA-526-7, 3.1.1. Additional requirements:
   1. Type: laser
   2. Central wavelengths: selectable to 1310 nm ±20 nm, 1550 nm ±20 nm
   3. Output stability +/- 0.40 dB from 0 to 50 degrees C
   4. Long term output stability +/- 0.10 dB at 25 degrees C
   5. Output power: –10 dBm, minimum

D. Power Meter
   1. Type: multi-wavelength photodetector
   2. Measurement wavelengths: selectable to 850 nm, 1300 nm, 1310 nm, and 1550 nm
   3. Measurement range: –60 dBm to +10 dBm
   4. Measurement resolution 0.01 dB
   5. Measurement accuracy: +/-10% at +10 to 0 dBm, +/- 5% at 0 to –50 dBm, and +/-10% at –50 to –60 dBm
   6. Measurement uncertainty: +/- 0.25 dB
   7. Storage: internal data storage for reference power measurement and test measurements
   8. Connections (for data transfer to computer): serial and/or USB

E. Length Measurement: The OLTS should be capable of measuring the optical length of the fiber.

F. Manufacturer, or equal:
1. AFL
2. Corning
   a. OTS-600 series optical loss test set
3. Fluke Networks
   a. DSX-5000 CableAnalyzer series test set equipped with fiber modules
   b. CertiFiber Pro series test set
4. Fluke Networks MultiFiber Pro series test set
   a. #MFPOWERMETER; MultiFiber Pro optical power meter
   b. #MFMULTIMODESOURCE; MultiFiber Pro 850 nm multimode source
   c. #MF1310SOURCE; MultiFiber Pro 1310 nm singlemode source
   d. #MF1550SOURCE; MultiFiber Pro 1550 nm singlemode source
5. Fluke Networks CertiFiber Pro series test set
6. JDS Uniphase
7. Softing
   a. WX4500; WireXpert test set with below test kit
      1) WX_AD_EF_MM2 kit for testing on single strand multimode links
      2) WX_AD_SM2 kit for testing on single strand singlemode links

2.3 FIBER OPTIC TEST CORDS AND LAUNCH CORDS

A. The fiber of the test cords and launch cords shall match as closely to the fiber of the segment-under-test as possible. At a minimum, the fiber type and performance (e.g., OS2) shall match and, ideally, the fiber should be by the same manufacturer.

B. Connectors of the test cords shall be compatible with (the same type as) the equipment (light source, power meter) and with the segment-under-test.

C. Test cords shall meet the following:

REQUIREMENT	MULTIMODE	SINGLEMODE
TIA Compliance	TIA-526-14-B, 3.3	TIA-526-7, 3.1.3
ISO/IEC Compliance	ISO/IEC 14763-3	ISO/IEC 14763-3
Reference Grade	Yes (per ISO/IEC 14763-3)	Yes (per ISO/IEC 14763-3)
End Face Compliance	IEC 6100-3-35	IEC 6100-3-35
Loss Performance, per Connector	≤ 0.1dB at 850nm and 1300nm	≤ 0.2dB at 1310nm and 1550nm
Loss Measurement Technique	Per FOTP-171 D2	Per FOTP-171 D3
PC Finish	Not required	Connectors shall inhibit Fresnel reflections (i.e., have a “PC” finish)
Length for Tier 1 Loss	1 m to 5 m	1 m to 5 m

2.4 CLEANING APPARATUS

A. Cleaning apparatus shall remove skin oil, isopropyl alcohol, graphite, dust, and other contaminants from connector end faces, and shall be able to clean both unattached connectors and connectors inserted into adapters.

B. Manufacturer, or equal:
   1. AFL
      a. #8500-05-0002MZ; one-click cleaner for 1.25mm ferrules (LC/MU)
   2. Corning
      a. CLEANER-PORT-LC
   3. Fluke
      a. #NFC-IBC-1.25mm; IBC OneClick cleaner, for 1.25 mm ferrules (LC, MU connectors)

PART 3 - EXECUTION

3.1 SAFETY

A. Safety: Operate test equipment that contains a laser or LED in accordance with ANSI Z136.2.

B. Adhere to the precautions described in TIA-526-14-B, 5.1.

C. Adhere to the equipment manufacturer’s instructions during testing.

3.2 FIELD QUALITY CONTROL

A. Charge test equipment’s batteries to full capacity prior to each day's testing to ensure proper operation.

B. Cleaning:
   1. Only use approved cleaning apparatus and methods.
   2. Keep test equipment, connectors and adapters/coupling alignment sleeves clean at the test points prior to and during testing activities and measurements. During testing, clean connector end faces with each reconnection. The Engineer may, at their discretion, request the contractor halt testing activity and have the technician clean testing equipment, test cords, launch cords, connectors of the cables under test, and related apparatus.

3.3 TEST CORD VERIFICATION

A. Visual Verification: Prior to accepting test cords for use in testing, inspect cords and connectors.
   1. Visually inspect each cord to ensure the cordage has no damage and the connectors are firmly attached to the cordage. If the cordage is undamaged and the connectors are firmly and properly attached, then the connector end faces may be inspected (go to next step). Otherwise, the cord may not be used for testing.
   2. Visually inspect each connector end face using a digital inspection microscope to ensure each end face is clean (no contamination) and free of defects (scratches, pits, chips, etc.) that would adversely affect measurement and repeatability. If the connector end face is clean with no defects and meets IEC 6100-3-35, then the cord may be used for testing. Otherwise, go to next step.
   3. If contamination is seen during end face visual inspection (step described above), then clean the end face using equipment and methods of TIA-526-14-B 5.6 [for multimode] or TIA-526-7 5.7 [for singlemode]. After cleaning, visually inspect the connector end faces using a digital microscope. If the connector end face is clean with no defects and meets

IEC 6100-3-35, then the cord may be used for testing. If, after cleaning, the end faces still exhibit scratches, pits, and/or other defects/imperfections, do not use this cord for testing.

4. Once the cord is acceptable and if the microscope has storage capability, record an image of the connector end face (for inclusion in the test report).

B. Test Cord Performance Verification
   1. Validate performance of cords for testing only if no defects are observed during visual inspection.
   2. Connect Test Cord #1 to the light source and to the power meter.
   3. Store the measured light value into the power meter as the reference power (P_{ref}).
   4. Disconnect Test Cord #1 from the power meter. Do not disconnect Test Cord #1 from the light source.
   5. Connect the 'open' end of Test Cord #1 to an adapter (of matching connector type). Connect one end of Test Cord #2 to that adapter and the other end of Test Cord #2 to the power meter.
   6. The value displayed on the power meter represents the test cord #2 connector loss at the adapter.
   7. Flip the ends of Test Cord #2 so that the end connected to the power meter is now connected to the adapter (attached to test cord #1), and the end connected to the adapter is now connected to the power meter.
   8. The value displayed on the power meter represents the test cord #2 connector loss at the adapter (opposite end as previous measurement).
   9. Only accept and use test cords meeting the loss values noted in Part 2.
   10. Repeat this test procedure from the beginning reversing the test cords in order to verify the performance of test cord #1.
   11. Documentation of test cord verification is not required.

3.4 TIER 1 | OPTICAL POWER LOSS TESTING REQUIREMENTS AND PROCEDURES

A. Test Equipment Preparation
   1. Bring test equipment to room temperature – approximately 72 degrees F.
   2. Power on the OLTS (or light source and power meter) for at least 5 minutes prior to setting a reference or obtaining measurements.
   3. Do not power off test equipment during testing activity. Should the test equipment power off, fully complete setting a reference.
   4. Set the test routine parameters to meet the testing requirements of this section.

B. Connection Preparation
   1. Prior to connecting test cords to the test equipment and to the cable-under-test, prepare connector end faces of the test cords and cable-under-test in accordance with IEC 6100-3-35 using approved cleaning equipment.

C. Visual Inspection:
   1. Prior to connecting test cords, visually inspect each connector end face of the cable-under-test using a digital inspection microscope to ensure each end face is clean (no contamination) and free of defects (scratches, pits, chips, etc.) that would adversely affect performance. Once the connector end face is clean with no defects and meets IEC 6100-3-35, record the image for inclusion in the test report submittal.
   2. If contamination is seen during end face visual inspection, then clean the end face using equipment and methods of TIA-526-14-B 5.6 [for multimode] or TIA-526-7 5.7 [for singlemode]. After cleaning, inspect the end faces using a digital inspection microscope. If the connector end face is clean with no defects and meets IEC 6100-3-35, then record the image for inclusion in the test report submittal. If, after cleaning, the end faces still

exhibit scratches, pits, and/or other defects/imperfections, remove the connector and reterminate the fiber with a new connector.

D. Setting a Reference
   1. Follow the test equipment manufacturer's initial adjustment and set up instructions.
   2. Set the light source and power meter to the same wavelength.
   3. Set the power meter to relative power measurement mode
   4. Set the meter to display power levels in dBm.
   5. Upon a stable power reading, set this as the reference power level following the manufacturer's instructions.
   6. Do not remove Test Cord #1 from the light source at any time (unless the test cord must be replaced, testing is complete, or the equipment is being put away for the evening).
   7. Do not bend the test cords smaller than 20 times the cord diameter (this may induce loss into the cord, which will reduce the accuracy of the measurement).

E. Measuring Multimode Passive Link Insertion Loss
   1. Only use cords that satisfy the test cord verification (see previous article) requirements. Do not use any cord with observed defects during testing.
   2. Connect test equipment, test cords, and cable-under-test per the Method noted in the Table under article 1.01 of this section.
   3. Do not disconnect the test cord from the light source. Should the test cord be disconnected from the light source, fully complete setting a reference.
   4. Do not bend the test cord smaller than 20 times the cord diameter during testing activities (this may induce loss into the cord reducing the accuracy of the measurement).
   5. Test each segment of installed cable plant according to the table under article 1.01 of this section.
   6. Store the measured insertion loss per segment into the test equipment.

F. Measuring Singlemode Passive Link Insertion Loss
   1. Connect test equipment, test cords, and cable-under-test per the Method noted in the Table under article 1.01 of this section.
   2. Use launch conditions described in FOTP-78 and employ a method to remove high-order propagating modes. A method to select a mode filter is described in FOPT-77.
   3. Do not disconnect the test cord from the light source. Should the test cord be disconnected from the light source, fully complete setting a reference.
   4. Do not bend the test cord smaller than 20 times the cord diameter during testing activities (this may induce loss into the cord, which will reduce the accuracy of the measurement).
   5. Test each segment of installed cable plant according to the table under article 1.01 of this section.
   6. Store the measured insertion loss per segment into the test equipment.

G. Recorded Test Measurements.
   1. Measurements shall carry a precision through at least one significant decimal place.

END OF SECTION 27 08 21

SECTION 27 11 00

COMMUNICATIONS EQUIPMENT ROOMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Buildout / fit-up of communications equipment rooms.

B. Base Bid Work
1. The work under this section includes materials, accessories, fasteners, etc., and the labor and associated services required to buildout / fit-up telecommunications equipment rooms, and includes coordination through the General Contractor with other trades. This specification lists major equipment but not every fastener, anchor, assembly hardware, support, brace, etc., required for a complete and professional installation.
2. Submittals – pre-construction and closeout submittals
3. Coordination Requirements and Final Layout
   a. The contract drawings show basic room layouts and the minimum anticipated equipment. The layouts and equipment shown are neither final nor exhaustive. Undoubtedly, there will be more equipment, other building system equipment panels, etc., that will end up in telecom rooms. Therefore, it is imperative that an entity coordinate the final constructed layout of telecom rooms and placement of inevitable equipment and services that ultimately land in these rooms. The work of this section includes assuming responsibility for coordinating final layout for other equipment not necessarily identified in the contract drawings (or even known at this time, such as equipment panels for other systems) within telecom rooms as required for a complete and professional installation. Coordinate throughout the entire construction team regarding others' needs to house equipment (such as equipment panels and control panels – BMS, fire alarm, etc.) within telecom rooms. Determine the final layout for telecom rooms.
   b. Electrical: Coordinate the power service with electrical contractor to ensure proper placement of lighting, sequencing of power service to rack bay, and other issues related to electrical trade.
   c. Mechanical: Coordinate the cooling service with mechanical contractor to ensure proper placement of equipment, ducts, etc., and other issues related to mechanical trade.
   d. Owner: Coordinate room-ready requirements and schedule with Owner (to allow Owner to plan and execute installation of OFOI telecommunications/network equipment).
   e. Based on this coordination, determine final equipment locations and final layout per telecom room.
4. Rack Bays:
   a. Provide completely assembled equipment racks, including seismic anchoring of the racks to the building structure. Provide fasteners and parts required to complete the installation.
   b. Provide vertical management sections as shown on the drawings.
   c. Provide horizontal management panels as shown on the drawings.
   d. Provide non-seismic stiffeners (or "kickers") at the end of each rack bay to the structure above or to overhead cable support as needed to mitigate sway and to stabilize the rack bay.

e. Provide power strips as shown on the drawings.
f. Provide bonding (also refer to 270526).

5. Overhead and Vertical Cable Support:
   a. Provide overhead cable support system, trapeze and wall supports, anchoring (e.g., to the underside of the structure above), accessories, fasteners, etc., required for a complete installation.
   b. Provide seismic bracing for the overhead cable support system, including layout, configuration, detailing, and seismic calculations.
   c. Provide drop-out as shown on Drawings.
6. UPSs
   a. Provide in-rack UPS systems as shown on the drawings.
7. Cable, wire and patch cord management
8. Identification tags, plates and labeling
9. Warranty

C. Work Covered Under Other Sections
1. Plywood backboards
2. Bonding
3. Grounding busbars
4. Conduit and device boxes
5. Power service to and within the room, and power service to the racks
6. Cooling service to and within the room and controls
7. Lighting
8. Fire / life safety

D. Related Divisions and Sections
1. Consult other Divisions, determine the extent and character of related work, and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable system.
2. Drawings, general provisions of the Agreement, and Division 01 apply to this Section.
3. Comply with the Related Sections requirements of section 270000 “Basic Communications Requirements”
4. Refer to section 270526, “Communications Bonding”, for related work.
5. Seismic Calculation requirements of section 270000, Article 1.05, apply to this Section.

1.2 REFERENCES

A. Comply with the References requirements of section 270000.

B. In additional to those codes, standards, etc., listed in section 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
1. EIA/ECA-310-E, “Cabinets, Racks, Panels, and Associated Equipment”

1.3 DEFINITIONS

A. Definitions as described in section 270000 shall apply to this section.

B. In addition to the “Definitions” of section 270000, the following list of terms as used in this specification defined as follows:
1. “BDF”: Building Distribution Facility
2. “IDF”: Intermediate Distribution Facility

3. “EF”: Entrance Facility – applicable to telecom utilities, as defined in Public Utilities Commission regulations
4. “UPS”: Uninterruptible Power Supply – a system that provides conditioned power with batteries acting as a continuous power source for equipment during a utility power interruption

1.4 SYSTEM DESCRIPTION

A. General: Communications rooms shall fall into one of the following space titles:
   1. Entrance Facility
   2. Building Distribution Facility
   3. Intermediate Distribution Facility (IDF)

B. Telecommunications rooms shall fall into one of the following space titles and functions:
   1. Entrance Facility will serve the following functions:
      a. House the MPOE for telecommunications utility/ies (e.g., AT&T)
      b. House telecom utility’s termination fields and interface between telecom utility’s facilities and premises facilities
   2. Building Distribution Facility (BDF) will serve the following functions:
      a. House interbuilding twisted pair and fiber optic backbone cabling to IDFs within the same building
      b. House voice backbone crossconnect field and data backbone crossconnect field
      c. House network equipment (i.e. distribution switches) serving the same building
      d. House horizontal termination field, both voice and data, of devices served from this room (refer to floor plans for area served)
      e. House network equipment (i.e. access switch) serving users of the room’s service area
   3. Intermediate Distribution Facility (IDF) will serve the following functions:
      a. House intrabuilding twisted pair and fiber optic backbone cabling from BDF
      b. House horizontal termination field – both voice and data – of outlets served from this room (refer to floor plans for area served)
      c. House network equipment (i.e. access switch) serving users of the room’s service area

C. Clearances: Refer to the drawings for minimum clearances associated with racks, rack bays, and IT cabinets. If not explicitly shown, apply the following minimum clearances.
   1. 2-Channel Equipment Racks:
      a. Front: 40" clearance from channel’s front mounting flange
      b. Back: 57" clearance from channel’s back mounting flange
      c. End: 42" clearance between the wall or any protrusions and the closest portion of the rack bay (such as the vertical cabling section)

1.5 SUBMITTALS

A. Submittals of this section shall comply with the “Submittal” requirements of section 270000.

B. Quantity: Furnish quantities of each submittal as noted in section 270000.

C. Submittal Requirements at Start of Construction:
   1. Product Data Submittal
   2. Shop Drawings Submittal: Consisting of any proposed changes to room plans.

D. Submittal Requirements at Closeout:
   1. As-Built drawings; showing room layouts (floor layouts, overhead layouts), rack elevations, and other information pertinent to the built conditions
   2. O&M Manual, containing the final approved products and maintenance instructions

E. Substitutions
   1. Requests for substitutions shall conform to the general requirements and procedure outlined in section 270000.

1.6 QUALITY ASSURANCE

A. Comply with “Quality Assurance” requirements of section 270000.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with “Delivery, Storage and Handling” requirements of section 270000.

1.8 WARRANTY

A. Warrant work and products described within this section for a period of 1 year. Correct deficiencies within 24 hours of notification.

PART 2 - PRODUCTS

2.1 EQUIPMENT RACK – 2-CHANNEL TYPE

A. Application: Suitable for the support of termination apparatus, cable and cord management apparatus, network equipment, and other similar equipment, within a telecommunications room.

B. Material: High strength, lightweight 6061-T6 aluminum, extrusion construction.

C. Channel:
   1. Size: 3" deep, with flanges on each side (“double sided”)
   2. Flange: 1.265" wide by 0.25" thick, with mounting holes
   3. Mounting Holes: Threaded, spaced at 5/8" - 5/8" - 1/2", compatible with EIA/ECA-310-E
   4. Threading: #12-24 rolled, compatible with EIA/ECA-310-E
   5. RMU Markings: The RMU markings shall be permanently stamped on the ‘outside’ of both flanges on both channels.

D. Assembled Rack: Assembled rack shall feature 2 mounting channels, and shall be 7'-0" high (overall) by 19" mounting width (20.25" wide overall), and shall contain 45 EIA mounting spaces (1.75")

E. Load Rating: 1,000 lbswhen evenly distributed for the height of the rack (The rack’s load bearing capacity shall be certified.)

F. Finish: Black, powder coat

G. Compliances: The rack shall be UL listed.

H. Manufacturers:
   1. B-Line (Eaton)
      a. #SB556084XUFB; 2-channel rack, 7'-0"H (45U) x 19"Mnt, black

2.2 BASE GUSSET, FOR 2-CHANNEL EQUIPMENT RACK

A. Application: Gusset kit for stiffening and stabilization of critical joints at the base of an equipment rack.

B. Manufacturers:
   1. B-Line (Eaton)
      a. #SB556 GUSSET KIT FB; gusset kit, black

2.3 VERTICAL MANAGEMENT SECTIONS

A. Application: Suitable for cable routing, cord routing, and cord slack storage vertically within a rack bay.

B. The vertical management section shall be <double-sided> <single-sided> (i.e., the management section having covered cable guides on the front and flip-retainers on the rear).

C. Size & Capacity: <Refer to the drawings for sizes and configurations.7'-0" high by 6"12" wide, with 5-1/3" deep (minimum) cable storage capacity in back and 6" deep (minimum) cord storage capacity in front.

D. Mounting: The vertical management section having matching bolt holes for attachment to the rack.

E. Color: black (guides and cover).

F. Manufacturers:
   1. B-Line (Eaton) RCM+ Series vertical management sections
      a. #SB86086D084FB; vertical management section, 7'-0"H x 6"W, double sided, black
      b. #SB860812D084FB; vertical management section, 7'-0"H x 12"W, double sided, black

2.4 HORIZONTAL MANAGEMENT PANEL

A. Application: Suitable for installation into equipment rack for horizontal cord management. The horizontal management panel shall match (and fully integrate with) the vertical management sections.

B. The horizontal management panel shall be double-sided.

C. Size: 1U or 2U high (refer to drawings) by 19” mounting.

D. Color: black (guides and cover).

E. Manufacturers:
   1. B-Line (Eaton) RCM+ Series management panels
      a. black
      b. #SB87019D1FB; horizontal management panel, double sided, standard fingers, 1U, black
      c. #SB87019D2FB; horizontal management panel, double sided, standard fingers, 2U, black

2.5 LABEL PLATES

A. Application: Suitable to affix onto top angle of equipment rack or onto the top front of a frame/cabinet.

B. Label plate shall be engrave-able stock melamine plastic laminate substrate.

C. Size (example): 1"H x 6"L x 1/16"T.

D. Color: Black.

E. Lettering shall be white, engraved, 1/2" high.

2.6 CABLE RUNWAY

A. Application: Suitable for the support and management of telecommunications (and other low voltage) cables, either overhead or vertically on a wall, within telecommunications rooms.

B. Straight Sections and Fittings:
   1. Construction: Straight sections and fittings shall be constructed of two longitudinal side elements – “stringer”, with elements periodically crossing between stringers – “rung”. Straight sections shall be manufactured in 9'-11 ½" lengths with rungs spaced 12” on center, and welded to stringers.
   2. Material - stringer and rung: rectangular steel tube, 1-1/2" x 3/8" x 0.65" wall thickness

C. Compliances: Cable runway shall be UL listed.

D. Manufacturers:
   1. B-Line (Eaton) “Tubular Stringer (Boxed)” series
      a. #SB17U12BFB; cable runway, straight section, 12"W, black
      b. #SB17U18BFB; cable runway, straight section, 18"W, black
      c. #SB17U24BFB; cable runway, straight section, 24"W, black
      d. #SB17HRB12FB; cable runway horizontal sweep/90-degree fitting, 12"W, black
      e. #SB17HRB18FB; cable runway horizontal sweep/90-degree fitting, 18"W, black
      f. #SB17HRB24FB; cable runway horizontal sweep/90-degree fitting, 24"W, black
      g. #SB17VRB12FB; cable runway vertical sweep/90-degree fitting, 12"W, black
      h. #SB17VRB18FB; cable runway vertical sweep/90-degree fitting, 18"W, black
      i. #SB17VRB24FB; cable runway vertical sweep/90-degree fitting, 24"W, black
   2. B-Line (Eaton) Installation Accessories
      a. #SB211312KFB; wall angle support kit – for 12"W runway, black powder coat
      b. #SB211318KFB; wall angle support kit – for 18"W runway, black powder coat
      c. #SB211324KFB; wall angle support kit – for 24"W runway, black powder coat
      d. #SB21312KFB; wall triangle support kit – for 12"W runway, black powder coat
      e. #SB21318KFB; wall triangle support kit – for 18"W runway, black powder coat

f. #SB21B; end cap – neoprene, or #SB110A1B; end cap – PVC
g. #SB213312FB; rack-to-runway attachment kit – for 9" or 12"W runway, black powder coat
h. #SB213318FB; rack-to-runway attachment kit – for 18"W runway, black powder coat
i. #SB213324FB; rack-to-runway attachment kit, for 24"W runway, black powder coat

3. B-Line (Eaton) Cable/Cord Management Accessories
a. #SB212912UFB; rung drop out kit, 10"W cable runway, black powder coat
b. #SB212918UFB; rung drop out kit, 16"W, black powder coat
c. #SB212924UFB; rung drop out kit, 22"W, black powder coat

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the “Execution” requirements of section 270000.

3.2 EXAMINATION AND PREPARATION

A. Prior to installation, verify rooms are suitable for the construction scope of this section. Schedule work to prevent damage caused by other trades during their construction.

B. Prepare surfaces, such as floors, for permanent installation of products, such as racks.

3.3 INSTALLATION

A. Equipment Rack Bays
1. Equipment Racks
a. Pre-Installation:
1) Layout the racks within telecom rooms, and mark the floor where racks will be installed. Obtain written approval from either the Engineer or Owner prior to proceeding with the rack bay installation.
2) The layout shall include the correct amount of space between each rack for proper installation (according to manufacturer’s written instructions) of the vertical management sections.
3) The layout shall satisfy the clearance requirements under “System Description”.
b. Anchoring
1) Use anchors and methods of the approved seismic submittal.
2) Drill the structure using means approved for this project.
3) As required, scan the structural floor to identify reinforcing bar and other elements that cannot be interrupted using means approved for this project (e.g., X-ray).
4) Anchor racks to the structural floor at four points.
5) Brace racks overhead to overhead cable support where shown on the drawings.
c. Seismic Bracing: As required for seismic bracing (determined during pre-construction seismic detailing and calculations), provide bracing to the structure using approved means and fasteners/anchors.
d. Leave no fastener loose and un-torqued.

e. Bonding: Bond rack bays to approved ground using approved means, configurations and products. Also refer to section 270526 for additional information on bonding.
f. Sway Mitigation: As directed by the Owner, install a brace (“kicker”) form the rack bay to the structure above or to overhead cable support as needed to mitigate sway and to stabilize the rack bay.

2. Vertical Management Sections
   a. Bolt vertical management sections to the equipment racks at the points designed by the manufacturer and per the manufacturer’s installation instructions.
   b. Leave no fastener loose and un-torqued.
3. Horizontal Management Panels
   a. Install horizontal management panels as required.
   b. Leave no fastener loose and un-torqued.
4. Accessories
   a. Furnish 1 bag of rack mounting screws per room. Attach the screws directly to the rack (visible for the punch walk).

B. Overhead Cable Support
1. Install support apparatus (e.g., brackets and threaded rod with strut) for overhead cable management system. Install the system per the manufacturer’s instructions and hung from overhead or braced to the wall using appropriate fasteners.
2. Install parts required for complete installation (e.g., mounting brackets, splice kits, hardware, etc.).
3. Tolerances
   a. Install overhead cable support as shown on the drawings.
4. Interface with Other Work: Coordinate the installation of the overhead cable support with other trades. Trapeze supports and hanger rods (“all-thread”), for example, may be shared to lower overall construction cost.

C. Vertical Cable Support
1. Install cable runway installed vertically for use to support cables routing vertically within telecommunications rooms at the locations as shown on the drawings.
2. Install parts required for complete installation (e.g., vertical mounting brackets, bolts, etc.).
3. When using cable runway, install the runway such that the rungs are facing outward (the greater distance from the rung to the stringer edge is facing inward).

D. Horizontal Power Strips
1. Install horizontal power strips as shown on the drawings. If not explicitly shown, coordinate the installation height with the Owner / Owner’s Representative. Install fasteners and parts required to complete the installation.
2. Route the input cord within designated cable management and install cord fasteners to prevent movement of the input cord. Plug the input cord into the receptacle designated by the Owner / Owner’s Representative.

E. UPSs (In-Rack Systems)
1. Install UPSs as shown on drawings. If not explicitly shown, install one UPS per telecommunications room. Install the UPS at the bottom of the left-most rack, including fasteners and parts required for a complete installation.
2. Plug the UPS into the electrical service designated by the Owner.
3. .

F. Track Busway Power Module
   1. Coordinate power modules to balance load between track busway phases. Since each IT cabinet in the Equipment Room requires two power modules, provide modules that plug into phases A and B for the first cabinet, C and A for the next cabinet, B and C for the next, and so on.

3.4 LABELING

A. General Requirements: Labeling and identifier assignment shall conform to the TIA-606 standard and as approved by Owner before installation.

B. Equipment Rack Label Requirements: Provide two label plates per rack. Permanently affix label plate as shown on the drawings or (if not shown) centered on the rack's front top angle and back top angle

C. Identifier Assignment
   1. Equipment Racks
      a. First field: the BDF/IDF room's identifier; for example: "AD1.1".
      b. Second field: the rack number (sequential numeral); for example: "R01".
      c. Example; "AD1.1-R01"

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the work of this section compliant to the requirements of section 270000.

B. Comply with system acceptance and certification requirements of section 270000.

END OF SECTION 27 11 00

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 27 13 13

COMMUNICATIONS BACKBONE ISP TWISTED PAIR CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Backbone ISP (inside plant/indoor) twisted pair cabling.

A. Base Bid Work
   1. Provide pre-construction services (e.g., submittals, coordination with other trades, etc.), materials, apparatus, labor, tools, equipment, and transportation required for complete communications backbone twisted pair cabling described in this section and shown on related drawings.
   2. The related drawings are diagrammatic in nature and require shop drawings to complete the detailed design of the telecommunications infrastructure.
   3. In general, the base bid work includes:
      a. Submittals
      b. Backbone inside plant (riser) twisted pair (copper) cables and termination apparatus
      c. Cable management
      d. Crossconnects
      e. Cable identification tags and system labeling
      f. Closeout documents
      g. Warranty

B. Related Sections
   1. Comply with the Related Sections requirements of section 270000.
   2. 270526, “Communications Bonding”
   3. 270811, “Communications Twisted Pair Testing”
   4. 270528, “Communication Building Pathways”
   5. 270536, “Communication Building Pathways – Cable Trays”
   6. _, “Communications Firestopping”

C. Work Covered Under Other Sections
   1. Pathways: The communications pathways (backbone conduits, riser sleeves, cable tray, etc.) work will be covered under another section. Refer to the drawings for size/capacity and route information.
   2. Rooms: Build out (e.g., backboards, overhead and vertical cable runway, etc.) of the rooms (BDFs, IDFs) will be covered under another section. Refer to the drawings for build out information.
   3. Testing: The backbone twisted pair cabling testing requirements are covered under another section. Refer to section 270811 for testing requirements.

1.2 REFERENCES

A. Comply with References requirements of section 270000.

B. In addition to the codes and standards listed in section 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 444, “Communications Cables”
      b. UL 497B, “Protectors for Data Communications and Fire-Alarm Circuits”
      c. UL 1581, “Reference Standard for Electrical Wires, Cables, and Flexible Cords”
      d. UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”
      e. UL 1863, “Communications-Circuit Accessories”
   2. Insulated Cable Engineers Association (ICEA)
      a. ANSI/ICEA S-90-661, “Category 3, 5, and 5e Individually Unshielded Twisted Pair Indoor Cable for Use In General Purpose and LAN Communication Wiring Systems”
      b. ICEA S-102-700, “ICEA Standard For Category 6 Individually Unshielded Twisted Pair Indoor Cables (With Or Without An Overall Shield) For Use In Communications Wiring Systems Technical Requirements”
   3. Telcordia
      a. GR-111, “Generic Requirements for Thermoplastic Insulated Riser Cable”

1.3 DEFINITIONS

A. Refer to section 270000 for Definitions.

B. In addition to those Definitions of section 270000, the following list of terms as used in this specification defined as follows:
   1. “ALVYN”: sheath type consisting of corrugated polymer-coated aluminum shield with and adhered flame retardant jacket
   2. “ARMM”: Bell system cable type (shielded riser)
   3. “CMR”: Communications Media Riser [NEC riser/non-plenum rating]
   4. “ISP”: Inside Plant [cabling]
   5. “PE”: Polyethylene
   6. “PIC”: Plastic Insulated Conductor
   7. “PVC”: Polyvinyl Chloride
   8. “PVDF”: Polyvinylidene fluoride

1.4 SYSTEM DESCRIPTION

A. Backbone twisted pair cabling shall consist of the cabling from the main telecommunications room to the telecommunications rooms or other locations that require analog, digital, or other non-network telecommunications services. Refer to the associated drawings for graphic representation of the system requirements, cabling routes, and quantities.
   1. Refer to other sections for pathways and cable support.
   2. Refer to other section for testing.

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of section 270000.

B. Quantity: Furnish quantities of each submittal as noted in section 270000.

C. Substitutions: Conform to substitutions requirements and procedures in section 270000.

D. Submittal Requirements Prior To Start Of Construction:
   1. Product Data submittal, indicating specifications and conformance with CEC, UL, TIA listings, and other applicable certifications.
   2. Sample Submittal, consisting of the following components:
      a. <sample products>.
   3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for Division 27.
   4. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations.

E. Submittal Requirements at Closeout:
   1. As-built drawings
   2. Crossconnection records/cut sheets
   3. O&M Manuals

F. Substitutions
   1. Requests for substitutions shall conform to the general requirements and procedure outlined in section 270000.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of section 270000.

B. Contractor Qualifications
   1. In addition to the Contractor Qualifications requirements of section 270000, the Contractor shall be manufacturer certified to install the proposed and submitted cabling system and to provide an extended warranty. Provide satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid submission.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of section 270000.

1.8 WARRANTY

A. The telecommunications cabling system, as specified in this section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover electrical performance of cabling system to the specific category per TIA-568 performance criteria for backbone cabling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Berk-Tek (no other substitutions allowed)

2.2 HORIZONTAL CABLE – CAT6A U/UTP RISER RATED (CMR)

A. Application: Suitable for indoor installation, within ceiling space in primary and secondary pathways, within access/raised floor space.

B. Conductors:
   1. Insulated Conductors: 23 AWG solid copper, fully insulated with a flame retardant thermoplastic material (material = PVC, or similar).
   2. Twisted Pairs: Two insulated conductors “twisted” into a “pair” (twisted pair) color-coded to industry standards (EIA-230).

C. Cable Sheath:
   1. Shielding: none
   2. Outer Jacket: seamless outer jacket (material = PVC, or similar) applied to and completely cover the internal components (twisted pairs).

D. Flame Rating: CMR, UL listed as such, and the rating shall be printed on the jacket.

E. Electrical and Mechanical Performance: Meet or exceed requirements of TIA-568 standard series, ANSI/ICEA S-116-732, ISO 11801 Class E_A Edition 2.2, and IEEE Std. 802.3an channel for CAT6A cabling.

F. Limited Power: UL certified as “Limited Power (LP)”, and the rating shall be printed on the jacket.
   1. Listed to 0.5 A per conductor.

G. Jacket marking: “CMR–LP (0.5A)”

H. Manufacturer:
   1. Berk-Tek “LANmark-XTP” Series CAT6A U/UTP Riser Rated (CMR) Cable
      a. #11082062; CAT6A 4 pair U/UTP cable “LANmark-XTP”, CMR, blue

2.3 SHIELDED TWISTED PAIR CABLES – NON-PLENUM (ARMM)

A. Application:
   1. Cable shall be suitable for indoor installation, between floors in vertical riser system, under access flooring, and through overhead ceiling space (in cable tray, conduit, and/or hangers).
   2. Each cable run shall be a continuous single cable, homogenous in nature; splices are not permitted.
   3. Twisted pair PIC type cable, air core, with an “ALVYN” sheath, compatible with Bell System type “ARMM”.

B. Conductors / Pairs:
   1. Annealed solid copper, 24 AWG
   2. Fully insulated, consisting of an inner layer of expanded polyolefin, covered with an outer layer (skin) of solid PVC.
   3. Conductors shall be twisted into pairs. Twisted pairs shall be stranded into 25-pair bundles and into units (and super units, if required by pair count).
   4. Twisted pairs and units (supper units, if necessary) shall be color-coded to industry standards (ANSI/ICEA Publication S-80-576, and EIA-230).

C. Core & Sheath:
   1. Cable core shall have a tape applied longitudinally (wrapped around its entirety).
      a. Tape Material: non-hydroscopic polypropylene film, or equivalent.
   2. Sheath Type: “ALVYN”. Sheath shall consist of an inner shield and an outer jacket.
      a. Shield: Aluminum, 0.008”, corrugated tape applied longitudinally, with an overlap.
      b. Jacket: Flame-retardant PVC, adhesively bonded to shield.

D. Cable shall be NEC rated as CMR cable and UL listed as such.

E. Electrical performance of the twisted pairs and overall cable shall comply with TIA-568 requirements for Category 3 UTP cabling, minimum.

F. Manufacturers, or equal:
   1. General Cable Air Core Cables “Foam Skin ALVYN Riser Cable” series cables.
   2. Belden
      a. #22713010; 25 pair, 24 AWG, ARMM type, gray, CMR rated
   3. General Cable
      a. #2019000; 25 pair, 24 AWG, ARMM type, gray, CMR rated

2.4 TERMINATION APPARATUS – RACK-MOUNT 110 TYPE

A. Application:
   1. Termination apparatus shall be “110 block” type.
   2. Termination apparatus shall be suitable for installation within a telecommunication facility for the termination of the backbone twisted pair cables specified within this section.
   3. Termination apparatus shall be horizontally oriented and suitable for rack-mount installations.
   4. Termination apparatus, accompanied by the quantity of management panels, shall provide for both horizontal and vertical routing of cords and crossconnect wires, as shown on the drawings.

B. Configuration: Rack-mount 110 block ‘base unit’ shall consist of the following components:
   1. Rack mount bracket (19-inch rack mount, 4U high), qty = 1
   2. Wiring block (100-pair, no legs), qty = 2
   3. IDC connectors (5-pair “C5 clips”), qty = 48
   4. Label holders, qty = 4
   5. Labels, qty = 4
   6. Horizontal ‘trough’ (cord/wire manager), qty = 2

C. Manufacturer:
   1. Leviton
      a. #41AB6-1F4; Category 6, 100-pair, 110 block w/legs &C4 clips Kit

2.5 CROSSCONNECT WIRE

A. Crossconnect wire shall be suitable for installation within a telecommunication facility and fully compatible with the termination apparatus specified within this section.

B. Crossconnect wire shall be manufactured from a single, continuous length of insulated wire, homogenous in nature; splices are not permitted. Factory splices of insulated conductors are expressly prohibited.

C. Conductors:
   1. Conductors: 24 AWG solid copper
   2. Insulation: fully insulated conductors with a flame retardant thermoplastic (such as PVC, or equivalent)
   3. Twisted Pairs: Two insulated conductors “twisted” into a “pair” (twisted pair), individually color-coded

D. Manufacturer, or equal:
   1. Belden B-Plus Crossconnect Wire
      a. #22208250; crossconnect wire, 1 pair, Wh/Bl
      b. #22208253; crossconnect wire, 1 pair, Wh/Bl, spool
      c. #22208260; crossconnect wire, 2 pair, Wh/Bl//Wh/Or
      d. #22208266; crossconnect wire, 3 pair, Wh/Bl//Wh/Or//Wh/Gr
      e. #22208270; crossconnect wire, 4 pair, Wh/Bl//Wh/Or//Wh/Gr//Wh/Br
   2. CommScope
      a. #CCW-F 1/24 S1000; crossconnect wire, 1 pair, Whi-Red / Red-Whi
      b. #CCW-F 1/24 S1000; crossconnect wire, 1 pair, Whi-Blu / Blu-Whi
   3. General
      a. #7023864; crossconnect wire, 1 pair, Red-Whi / Whi-Red
      b. #2114385; crossconnect wire, 1 pair, Red-Yel / Yel-Red
      c. #2114200; crossconnect wire, 1 pair, Red-Grn / Grn-Red
      d. #2114369; crossconnect wire, 1 pair, Red-Blu / Blu-Red
      e. #7023708; crossconnect wire, 1 pair, Red-Blk / Blk-Red
      f. #7041916; crossconnect wire, 1 pair, Blk-Yel / Yel-Blk
      g. #7023733; crossconnect wire, 1 pair, Org-Whi / Whi-Org
      h. #7023781; crossconnect wire, 1 pair, Grn-Whi / Whi-Grn
      i. #7036759; crossconnect wire, 1 pair, Blk-Whi / Whi-Blk
      j. #7023716; crossconnect wire, 22 AWG, 2 pair, Blk-Whi/Whi-Blk // Org-Whi/Whi-Org
      k. #2114363; crossconnect wire, 1 pair, Whi-Org / Org-Whi
      l. #2114364; crossconnect wire, 1 pair, Whi-Grn / Grn-Whi
   4. Superior Essex
      a. #12-101-13; crossconnect wire, 1 pair, Red-Whi
      b. #12-102-13; crossconnect wire, 1 pair, Red-Yel
      c. #12-103-13; crossconnect wire, 1 pair, Whi-Blu
      d. #12-104-13; crossconnect wire, 1 pair, Vio-Blu
      e. #12-105-13; crossconnect wire, 1 pair, Blk-Whi

2.6 LABELS

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels for Cables
   1. Labels shall be adhesive-backed and have a self-laminating feature.
   2. Labels shall fit the backbone cables listed above (i.e., shall fully wrap around the cable's jacket).
   3. Printable area should be 1 inch wide x 0.5 inch high, or larger.
   4. Printable area color shall be white.
   5. Manufacturer, or equal:
      a. Brother P-Toch Labels
         1) #TZe231; .50" / 12mm Black on White, 110 Blocks, fiber enclosures
         2) #TZeFX241; .75" / 18mm Black on White, Flex Tape – Cable Rapping

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of section 270000.

3.2 EXAMINATION AND PREPARATION

A. Rooms: Prior to installation, verify equipment rooms are suitable to accept the backbone twisted pair cables and terminations.

B. Pathways: Prior to installation verify that pathways and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, "True Tape" the conduits).

C. Cable Integrity: Prior to installation, verify the twisted pair cable is fully operational – both cable sheath and twisted pair conductors. Documentation of pre-installation testing is not a close out requirement and is the responsibility of the Contractor.

3.3 INSTALLATION

A. Backbone Cable Installation and Routing
   1. Cable runs shall have continuous sheath continuity, homogenous in nature; splices are not permitted.
   2. Maximum cable length of 500 meters from the termination within the Entrance Facility to the termination in Telecommunications Room.
   3. Placement
      a. Place cables within designated pathways.
      b. Maintain a minimum bend radius of 6 times the cable diameter during and after installation.
      c. Maintain pulling tension within manufacturer's limits.
      d. Place and suspend cables in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables if damaged during installation
      e. Place a pull rope along with cables where run in conduit and spare capacity still exists in the conduit. Tie off ends of the pull rope.

4. Routing
    a. When routing horizontally within telecommunications rooms, utilize the overhead cable support. When routing vertically within telecommunications rooms, utilize the vertical cable support and provide cable ties every 24 inches on center using.
    b. Route cables a minimum of 6" away from power sources to reduce interference from EMI.
5. Termination
    a. Provide 15 feet cable slack loop at each end of the run. Store slack in overhead cable support or as noted on drawings.
    b. Properly relieve strain from cables at termination points per manufacturer's instructions.
    c. Terminate twisted pairs onto the termination apparatus in accordance with manufacturer's latest instructions and TIA-568 standard installation practices.
    d. .
    e. Perform post-installation testing as described in section 270811.

B. Termination Apparatus
1. Provide accessories required for a complete installation.
2. Install the termination apparatus to the dimensions shown on the drawings. If the dimensions are not shown, install the termination apparatus such that the bottom row of terminations is no lower than 24 inches (+/- 3") AFF and the top row of terminations is no higher than 60 inches (+/- 3") AFF.
3. Mount termination apparatus plumb and square.

C. Crossconnects
1. In the MPOEMDF, provide one 1-pair crossconnect wire to length between the Telco field and the backbone field based on the records from the IDF crossconnections to transport analog circuits or other Telco/utility services.
    a. Utilize the horizontal and vertical management components to properly route the crossconnect wire.
    b. Color:
        1) For analog circuits, provide: White-Red / Red-White
        2) For digital circuits, provide: White-Blue / Blue-White
    c. Splices in crossconnect wire are prohibited.
2. In the Telecom Rooms, provide patch cords as shown on the drawings (refer to the telecom cabling schedule).

3.4 LABELING

A. General Requirements
1. Labeling and identifier assignment and the label colors shall conform to the TIA-606 Administration Standard and as approved by Owner or Owner's Representative before installation.
2. Provide permanent and machine-generated labels; hand written labels will not be accepted.

B. Cable Labels
1. Label Format:
    a. Label type shall be wrap-around self-laminating.
    b. Label color shall be white background with clear laminating window.
    c. Text color shall be black; text height shall be 1/8" high, minimum, or #12 font size.

2. Provide labels on both ends of cables. Fully wrap label around the cable jacket. Install labels no more than 4 inches from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.

C. Termination Apparatus Labels
1. Use labels included in the product packaging. For substitutions, request approval by the Engineer.
2. Label color shall be whitefor respective field type, per TIA-606.
3. Text color shall be black, 3/32” high, minimum, or #10 font size.

D. Identifier Assignment
1. General: Separate label fields of the identifier with a hyphen.
2. Backbone ISP Twisted Pair Cables
a. The first field: the originating MDF/BDF room identity; for example: “AD1.1”.
b. The second field: the destination BDF/IDF room identify; for example: “AD3.1”.
c. The third field: the cable type; for example: “C25” (copper 25 pair).
d. The fourth field: beginning pair count served from originating room; for example: “01”.
e. The fifth field: ending pair count served from originating room; for example: “25”
f. Identifier Example: “AD1.1-AD3.1-C25-01-25”
g.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the work of this section compliant to the requirements of section 270000.

B. Remove and replace with new, at no cost to the Owner, cables or conductors failing to meet the indicated standards and not passing the testing requirements of section 270811. The Owner, or Owner’s Representative, will not accept the installation until testing has indicated a 100% availability of all cables and conductors or the Owner or Owner’s Representative has approved any deviation from this requirement.

C. Comply with system acceptance and certification requirements of section 270000.

END OF SECTION 27 13 13

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 27 13 23

COMMUNICATIONS BACKBONE ISP FIBER OPTIC CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Backbone ISP (indoor) fiber optic cabling.

B. Related Sections
1. Comply with the Related Sections paragraph of Section 270000.
2. 270821 Communication Fiber Optic Testing
3. Section _ Communications Firestopping.

1.2 REFERENCES

A. Comply with References requirements of Section 270000.

B. In addition to the codes and standards listed in Section 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
   a. UL 1569, “Metal-Clad Cables”
   b. UL 1651, “Optical Fiber Cable”
   c. UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”
2. Insulated Cable Engineers Association (ICEA)
   a. ANSI/ICEA S-83-596-1994, “Fiber Optic Premises Distribution Cable”
   b. ”
3. Telcordia
   a. GR-20-CORE, Issue 3, “Generic Requirements for Optical Fiber and Optical Fiber Cable”
   b. GR-409-CORE, Issue 2, “Generic Requirements for Indoor Fiber Optic Cable”

1.3 DEFINITIONS

A. Refer to Section 270000 for Definitions.

B. In addition to those Definitions of Section 270000, the following list of terms as used in this specification defined as follows:
1. “MM”: Multimode [fiber type]
2. “OFCP”: Optical Fiber Conductive Plenum, plenum rating
3. “OFCR”: Optical Fiber Conductive Riser, non-plenum riser rating
4. “OFNP”: Optical Fiber Non-conductive Plenum, plenum rating
5. “OFNR”: Optical Fiber Non-conductive Riser, non-plenum riser rating
6. “OFN”: Optical Fiber Non-conductive, general purpose indoor rating
7. “PVC”: PolyVinyl Chloride
8. “SM”: Singlemode [fiber type]

1.4 SYSTEM DESCRIPTION

A. Work Covered Under Other Sections
   1. Pathways: The communications pathways (backbone conduits, riser sleeves, basketway, cable tray, etc.) work will be covered under another Section. Refer to the drawings for size/capacity and route information.
   2. Rooms: Build out (e.g., backboards, overhead and vertical cable support, etc.) of the telecommunications rooms will be covered under another Section. Refer to the drawings for build out information.

B. Base Bid Work
   1. Provide engineering, labor, materials, apparatus, tools, equipment, and transportation required to make a complete working telecommunications backbone fiber optic cabling system installation described in these specifications and shown on related drawings.
   2. The drawings are diagrammatic in nature, and require shop drawings to complete the detailed design of the telecommunications infrastructure.
   3. Consider Backbone cabling, as shown on drawings, as base bid work, unless otherwise noted, including terminations at both ends.
   4. In general, the base bid work includes:
      a. Submittals
      b. Backbone inside plant (riser) fiber optic cables and terminations
      c. Bonding (cable armor, termination apparatus, etc)
      d. Cable management
      e. Crossconnections / patching.
      f. Cable identification tags and system labeling
      g. Record Documents
      h. Warranty

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 270000.

B. Submittal Requirements Prior To Start Of Construction:
   1. Product Data Submittal, indicating conformance with NEC, UL, TIA/EIA listings, certifications and specifications.
   2. Sample Submittal, consisting of the following components:
      a. <sample products>
   3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for Division 27.
   4. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations

C. Submittal Requirements at Closeout:
   1. Copy of the manufacturer's printed reel documentation, including the following.
      a. Manufacturer's reel number
      b. Manufacturer's traceable batch number
      c. Length of the fiber cable on the reel
      d. Maximum attenuation
      e. Minimum bandwidth
   2. As-Built Drawings
   3. Crossconnection records/cut sheets
   4. O&M Manuals

D. Substitutions
   1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 270000.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 270000.

B. Contractor Qualifications
   1. In addition to the Contractor Qualifications requirements of Section 270000, the Contractor shall be manufacturer certified to install the proposed and submitted cabling system and to provide an extended warranty. Provide satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid submission.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of Section 270000.

1.8 WARRANTY

A. The backbone fiber optic cabling system, as specified in this section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover optical performance of cabling system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Berk-Tek (no other substitutions allowed)

B.

2.2 FIBER OPTIC CABLE – INTERLOCKED ARMOR PLENUM RATED

A. Application:
   1. Cable shall be suitable for indoor installation, between floors in vertical riser system, under access flooring, and through overhead ceiling space (in basketway, cable tray, conduit, and/or hangers).
   2. Optical transmission performance shall not be significantly affected by environmental fluctuations, installation, or aging.
   3. Materials shall not evolve hydrogen in quantities that will increase light attenuation.

B. Multimode 50/125 μm fiber strands shall meet or exceed the following geometry criteria:
   1. Core diameter = 50 μm, ±3.0 μm
   2. Cladding diameter = 125 μm, ±1.0 μm

3. Core/Cladding Concentricity = ≤ 3 μm
4. Minimum Tensile Strength = 100,000 psi

C. Multimode 50/125 μm fiber strands shall meet or exceed the following performance criteria:
1. Attenuation = 3.0 dB/km at 850 nm and 1.0 dB/km at 1300 nm wavelengths, maximum
2. Overfilled Bandwidth = 1,500 MHz•km at 850 nm and 500 MHz•km at 1300 nm wavelengths, minimum
3. Effective Modal Bandwidth = 2,000 MHz•km at 850 nm and 500 MHz•km at 1300 nm wavelengths, minimum

D. Singlemode fiber strands shall meet or exceed the following geometry criteria:
1. Core diameter = 8.3 μm
2. Mode field diameter = 8.8 μm, ±0.5 μm
3. Cladding diameter = 125 μm, ±1.0 μm
4. Core/Cladding Concentricity = ≤ 0.8 μm
5. Minimum Tensile Strength = 100,000 psi

E. Singlemode fiber strands shall meet or exceed the following performance criteria:
1. Attenuation = 0.7 dB/km at 1310 nm and 0.7 dB/km at 1550 nm wavelengths, maximum
2. Cutoff wavelength = 1260 nm
3. Dispersion = 3.5 ps/nm•km at 1285-1330 nm and 18 ps/nm•km at 1550 nm
4. Singlemode fiber shall meet the specifications of the following:
    a. International Telecommunication Union (ITU) ITU-T G.652.D classification for low water peak (LWP) singlemode fiber
    b. International Electrotechnical Commission (IEC) 60793-2-50 "Sectional Specification for Class B single-mode fibres", Class B1.3

F. Primary Coating:
1. Each fiber shall be completely covered with a “primary coating” (acrylate material).
2. Coating diameter = 250 μm, ±5 μm

G. Buffering:
1. Each coated fiber shall be fully covered with a material extruded over and directly onto the coating. This shall be the tight buffer. Tight buffer diameter = 900 μm, ±5 μm. Material = PVC, or equivalent flame retardant thermoplastic.
2. Buffered strands shall be individually color-coded to meet the requirements of ANSI/TIA/EIA-598-A-1995. (Also, ref. ANSI/ICEA S-83-596-1994, and EIA-230)

H. Cable Sheath:
1. Strength Element: The cable shall have an internal strength element such as aramid yarn (e.g., Kevlar).
2. Inner Jacket: The cable shall have a seamless inner jacket (material = PVC, or equivalent) applied to and completely covering the internal components (fiber strands, strength element, other).
3. Armor: The cable shall have an interlocking metallic armor applied spirally and longitudinally to and completely covering the cable.
4. Outer Jacket: The cable shall have a seamless outer jacket (material = PVC, or equivalent) applied to and completely covering the armor.
5. Tensile Strength: The cable shall have a 150-lb, minimum, rated load.
6. Flame Rating: NEC (Article 770) rated as OFCP, and UL listed as such.

I. Manufacturer:
   1. Berk-Tek
      a. #PDPK012FB3010/F5-I/O-C4(AQU); 12 strand, 50/125μm, interlock armor, aqua, OFCR rated
   2. Berk-Tek
      a. #PDPK012AB0707-I/O-C4C5(YEL); 12 strand, singlemode, interlock armor, yellow, OFCR rated
   3.
   4. Berk-Tek
      a.

2.3 FIBER OPTIC PATCH CORDS

A. Application
   1. Fiber optic patch cords shall be suitable for indoor installation within a telecommunications room within and/or between fiber patch panels.
   2. Cord shall be assembled from a single, continuous length of cordage, homogenous in nature; Splices are not permitted.

B. Cordage – Multimode 50/125um
   1. Conductors: Two 50/125um multimode tight-buffered fibers.
   2. Strength Element: Aramid yarn (Kevlar).
   3. Jacket: Flame-retardant PVC, or equivalent, in a 'zipcord' configuration.
   4. NEC rated as OFN (or higher), and UL listed as such.

C. Cordage – Singlemode
   1. Conductors: Two singlemode tight-buffered fibers.
   2. Strength Element: Aramid yarn (Kevlar).
   3. Jacket: Flame-retardant PVC, or equivalent, in a 'zipcord' configuration.
   4. NEC rated as OFN (or higher), and UL listed as such.

D. Connectors
   1. Multimode patch cords shall be either terminated via duplex LC connectors at both ends or terminated via duplex LC connectors to connect with the cable plant and via the connector type as required for connection to equipment.
   2. Singlemode patch cords shall be either terminated via duplex LC Ultra PC connectors at both ends or terminated via duplex LC-UPC connectors to connect with the cable plant and via the connector type as required for connection to equipment

E. Connector Loss
   1. Multimode: ≤ 0.5dB per mated pair at both 850nm and 1300nm.
   2. Singlemode: 0.5dB per mated pair at both 1310nm and 1550nm.

F. Manufacturer:
   1. Leviton
      a. #54DLC-M01; LC-LC Fiber Patch Cord, 50mm, OM4, 1 meter
      b. #54DLC-M03; LC-LC Fiber Patch Cord, 50mm, OM4, 3 meter
      c. #UPDLC-S01; LC-LC Fiber Patch Cord, Single-Mode, OS1, 1 meter
      d. #UPDLC-S03; LC-LC Fiber Patch Cord, Single-Mode, OS1, 3 meter

2.4 TERMINATION APPARATUS – FIBER OPTIC PATCH PANELS

A. Application:
   1. Fiber optic patch panels shall be an enclosed housing for protecting, storing and organizing the termination of fiber cable(s) and fiber strands, shall provide means to strain relieve and support of the specified cables, shall contain facilities to store fiber slack, and shall provide patch cord management.
   2. Fiber optic patch panels shall be passive physical equipment and apparatus used in terminating, interconnecting, and cross-connecting fiber optic cabling, shall possess a minimum fire resistant rating of UL94V-1, and shall conform to existing OSHA Health and Safety Laws.
   3. Fiber optic patch panels shall be rack-mountable.

B. Fiber optic patch panels shall come equipped with safety labels such as laser identification or warning labels as required by system considerations.

C. Manufacturer:
   1. Levinton
      a. #5R1UH-S03; Opt-X 2000i SDX – 1RU Fiber Enclosure, sliding tray, accepts 3 adapter plates, (72 LC's)
      b. #5F100-2QL; Fiber Adapter plate – 12 Fiber LC 50um, OM3/4
      c. #5F100-2LL; Fiber Adapter plate – 12 Fiber LC Single-Mode, OS2
      d. #5F100-PLT; Fiber Adapter Plate - Blank

2.5 FIBER OPTIC CONNECTORS

A. Multimode Fiber Optic Connectors – LC Type
   1. Materials:
      a. Ferrule: ceramic with pre-radiused finish/face
      b. Connector Housing: Plastic
   2. Connector shall have an integral strain relief feature, including a bend limiting rear boot.
   3. Manufacturer:
      a. Leviton
         1) #54PLC-M03; 1 – Fiber 50/125 um, OM4 LC, 3 meter

B. Singlemode Fiber Optic Connectors – LC Type
   1. Materials:
      a. Ferrule: ceramic (zirconia or alumina) with pre-radiused finish/face
      b. Connector housing: plastic
   2. Connector shall meet or exceed Ultra PC performance (LC-UPC).
   3. Connector shall have an integral strain relief feature, including a bend limiting rear boot.
   4. Manufacturer:
      a. Leviton
         1) #UPPLC-S03; 1 – Fiber Single-Mode, OS2 LC, 3 meter

2.6 LABELS

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels for Cables
   1. Labels shall be adhesive-backed and have a self-laminating feature

2. Labels shall fit the backbone cables listed above (i.e., shall fully wrap around the cable's jacket).
3. Printable area should be 1-inch wide x 0.5 inch high, or larger
4. Printable area color shall be white
5. Manufacturer:
    a. Brother P-Touch Labels
        1) #TZe231; .50" / 12mm Black on White, 110 Blocks, fiber enclosures
        2) #TZeFX241; .75" / 18mm Black on White, Flex Tape – Cable Rapping

2.7 MISCELLANEOUS

A. Fiber Slack Storage Reel: Leviton #48900-OFR

B. Velcro Cable Ties
1. Width: .75".
2. Color: Velcro cable ties the same color as the cable to which it is being applied.
3. Manufacturers:
    a. Panduit
        1) #HLS-15R-0 Black, 15' roll, cut to length.
    b. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with Execution requirements of Section 270000.

3.2 EXAMINATION AND PREPARATION

A. Pathways: Prior to installation verify pathways (conduits, etc.) and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, "True Tape" the conduits).

B. Rooms: Prior to installation, verify equipment rooms are ready for cables and terminations.

C. Prior to installation, verify cables and conductors are fully operational – both cable sheath and fiber strands. Pre-installation testing is the responsibility of the Contractor, though documentation of pre-installation testing is not a close out requirement.

3.3 INSTALLATION

A. Backbone Cable Installation, Routing, and Termination
1. Cable runs shall have continuous sheath continuity, homogenous in nature. Splices are not permitted anywhere.
2. Do not exceed 500 meters optical conductor length from the termination within the Entrance Facility/BDF IDF.

3. Placement
    a. Place cables within designated pathways.
    b. Maintain a minimum bend radius of 20 times the cable diameter during installation, and a minimum bend radius of 10 times the cable diameter after installation.
    c. Maintain pulling tension within manufacturer's limits.
    d. Place and suspend cables in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation.
    e. Do not use cable-pulling compounds for indoor installations.
    f. Provide 20 to 30 feet of cable slack at each end within the Telecommunications Rooms; store slack in fiber slack storage reel mounted on the wall.
    g. Place a pull rope along with cables where run in pathways and spare capacity in the pathway remains. Tie off ends of the pull rope.
4. Routing
    a. Within Telecommunications Rooms, neatly dress and organize cables on designated cable support apparatus (for example, overhead and vertical cable support), and fasten cables to cable support apparatus via tie wraps or Velcro-type straps.
5. Termination
    a. Properly relieve strain from cables at termination points (at/within the fiber optic termination panels) per manufacturer's instructions.
    b. Bond cable armor to grounding point (busbar) – refer to section 270526 for additional information.
    c. Terminate fiber strands via pigtail splicing at both ends using the specified fiber optic pigtail appropriate for the mode type of the fiber. Splicing type shall be fusion; mechanical splicing will not be accepted. Perform terminations in accordance with manufacturer's instructions.
    d. Provide required accessories and consumables for the complete termination of fiber strands.
    e. Provide 3 feet of unsheathed fiber (tight buffer) slack within the patch panel/termination enclosure at each end of the link. Properly store fiber slack in rear of patch panel into the 'routing rings', per manufacturer's instructions. Include 'extension' slack loop/fold in the rear of the shelf to allow for the drawer to be pulled out without putting tension on the fibers.

B. Fiber Optic Cable Termination Panel
1. Provide fully assembled termination panel in designated equipment rack; locate per drawings (if not shown, locate at the top). "Fully assembled" includes installation and mounting components and accessories such as adapter panels, coupling adapters, etc. required for operation.
2. Provide accessories required for proper installation of each termination panel, including connector panels and adapters.
3. Bond termination apparatus to grounding point (busbar) – refer to section 270526 for additional information.

3.4 LABELING

A. General Requirements
1. Labeling, identifier assignment, and the label colors shall conform to the TIA/EIA-606-A Administration Standard and as approved by Owner or Owner's Representative before installation.
2. Provide permanent and machine generated labels; hand written labels will not be accepted.

B. Cable Labels
   1. Label Format:
      a. Label type shall be wrap-around self-laminating.
      b. Label color shall be white background with clear laminating window.
      c. Text color shall be black; text height shall be 1/8” high, minimum, or #12 font size.
   2. Provide labels on both ends of cables. Fully wrap label around the cable jacket. Install labels no more than 4 inches from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.

C. Termination Apparatus Labels
   1. Use labels included in the product packaging. For substitutions, request approval by the Engineer.
   2. Label color shall be white for respective field type, per TIA/EIA-606-A.
   3. Text color shall be black, 3/32” high, minimum, or #10 font size.

D. Identifier Assignment
   1. General: Separate all label fields of the identifier with a hyphen.
   2. Backbone ISP Fiber Optic Cables
      a. The first field: the originating MDF/BDF room identity; for example: “AD1.1”.
      b. The second field: the destination BDF/IDF room identify; for example: “AD3.1”.
      c. The third field: the cable type; for example: “F6” (fiber optic, 50/125 multimode).
      d. The fourth field: beginning strand count served from originating room; for example: “01”.
      e. The fifth field: ending strand count served from originating room; for example: “12”
      f. Identifier Example: “AD1.1-AD3.1-F6-01-12”

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 270000.

B. Remove and replace with new, at no additional cost, cables with conductors failing to meet the indicated standards and not passing the testing requirements of Section 270821. The Owner, or Owner’s Representative, will not accept the installation until testing has indicated a 100% availability of cables and conductors or the Owner or Owner’s Representative has approved in writing any deviation from this requirement.

C. Comply with system acceptance and certification requirements of Section 270000.

END OF SECTION 27 13 23

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 27 15 13

COMMUNICATIONS HORIZONTAL TWISTED PAIR CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Horizontal twisted pair cabling

B. Base Bid Work
1. Provide pre-construction services (e.g., submittals, coordination with other trades, etc.), materials, apparatus, labor, tools, equipment, and transportation required for complete communications horizontal twisted pair cabling described in this section and shown on related drawings.
2. In general, the base bid work includes:
   a. Submittals
   b. Horizontal cables, terminations, and outlets
   c. Cable support and management
   d. Patch cords, and cord management
   e. Cable identification tags and system labeling
   f. Closeout documents
   g. Warranty
3. Identifiers and Labeling: The scope of work herein includes the responsibility for assigning identifiers to each horizontal cabling link and related cabling media in addition to providing physical labeling to each component.

C. Related Divisions and Sections
1. Comply with the Related Divisions and Sections requirements of section 270000
2. 270811, “Communications Twisted Pair Testing”
3. 271313, “Communications Backbone Twisted Pair Cabling”
4. 270528, “Communications Building Pathways”
5. 270533, “Communications Building Pathways – Conduits and Boxes
6. 270536, “Communications Building Pathways – Cable Trays”

D. Work Provided Under Other Sections
1. Pathways: Communications pathways (cable tray, conduits, stubs, etc.) are covered under another section. Refer to the drawings for type, size/capacity and route information. Refer to sections 270528, 270533 and 270536 and to the drawings for requirements, buildout information and layouts.
2. Rooms: Telecommunications room buildout (e.g., backboards, rack bays, overhead and vertical cable support, etc.) is covered under another section. Refer to section 271100 and to the drawings for requirements, buildout information and layouts.
3. Testing: The horizontal cabling system testing requirements are covered under another section. Refer to section 270811 for testing requirements.

E. Products installed but not furnished under this section
1. <Owner-furnished equipment>
2. <Wireless access points>

1.2 REFERENCES

A. Comply with the References requirements of section 270000.

B. In addition to the codes and standards listed in section 270000, comply with the latest edition (or as noted) of the following applicable specifications and standards except as otherwise shown or specified:
   1. National Fire Protection Agency (NFPA)
      a. NFPA 255, “Standard Method of Test of Surface Burning Characteristics of Building Materials”
      b. NFPA 259, “Standard Test Method for Potential Heat of Building Materials”
      c. NFPA 262, “Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces”
   2. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 444, “Communications Cables”
      b. UL 1863, “Communications-Circuit Accessories”
   3. Insulated Cable Engineers Association (ICEA):
      a. ICEA S-116-732, “Standard for Category 6 and 6A, 100 Ohm, Individually Unshielded Twisted Pairs, Indoor Cables (With Or Without An Overall Shield) for Use in LAN Communications Wiring Systems”
      b. ANSI/ICEA S-107-704, “Standard for Broadband Buried Service Wire, Filled, Polyolefin Insulated, Copper Conductor Technical Requirements”

1.3 DEFINITIONS

A. The Definitions in section 270000 apply to this section.

B. In addition, define the following list of terms as used in this specification as follows:
   1. “Cabling”: cabling consists of cables, connectors (jacks, plugs), termination apparatus (panels, blocks, outlets, etc.), consolidation points, connecting media (patch cords, line cords, etc.), and labeling/identification.
   2. “CAT6A”: Category 6 Augmented performance grade
   3. “Channel”: End to end transmission path; e.g., the Permanent Link and connecting media such as line cord (at the workstation), patch cord, and (if a full crossconnection is implemented) the crossconnect termination/connecting apparatus and equipment cord.
   4. “CMP”: Communications Media Plenum [plenum rating]
   5. “FEP”: Fluorinated Ethylene Propylene
   6. “F/UTP”: twisted pair cabling with an overall foil shield
   7. “FTP”: synonymous with “F/UTP”, unless otherwise noted
   8. “ID”: identifier
   9. “BDF”: Building Distribution Facility
   10. “PE”: Polyethylene
   11. “Permanent Link”: Test configuration for a horizontal cabling link excluding patch cords, equipment cords, and line cords; e.g., the permanent portion of the horizontal cabling to each outlet consisting of cable, consolidation point (if used), termination/connecting apparatus in the telecommunications and the connector at the outlet.
   12. “PVC”: Polyvinyl chloride
   13. “IDF”: Intermediate Distribution Facility
   14. “U/UTP”: twisted pair cabling with no shield
   15. “UTP”: synonymous with “U/UTP”, unless otherwise noted

1.4 SYSTEM DESCRIPTION

A. Horizontal twisted pair cabling shall consist of the cabling from telecommunications rooms to outlets/connectors at work areas, to equipment, to devices, or other items that require network connections or other telecommunications services.
   1. Refer to other sections for pathways and cable support.
   2. Refer to other section for testing.

B. Cabling Length Requirements: Note that cable length means the electrical length (pair length), not the sheath length. Also, length requirements must account for test equipment accuracy tolerances (for example, TIA568-C.2 allows for 10% uncertainty).
   1. The maximum electrical length of any permanent link shall not exceed 90 meters. If consolidation points or multi-user outlets are used, then the lengths shall not exceed those listed in the TIA-568 standard and the cabling system manufacturer's guidelines (whichever is shorter).
   2. The maximum electrical length of any channel shall not exceed 100 meters. If consolidation points or multi-user outlets are used, or if the total length of cords needs to exceed 10 meters, then the permanent link lengths shall not exceed those listed in the TIA-568 standard and the cabling system manufacturer's guidelines (whichever is shorter).
   3. The minimum electrical length of any permanent link shall be no shorter than as required by the manufacturer (as described in written guidelines).

C. Jack Wiring: Jacks shall be wired to T568B configuration.

1.5 SUBMITTALS

A. Comply with the Submittals requirements of section 270000.

B. Quantity: Furnish quantities of each submittal as noted in section 270000.

C. Substitutions: Conform to substitutions requirements and procedures in section 270000.

D. Submittal requirements prior to the start of construction:
   1. Product Data submittal, indicating specifications and conformance with CEC, UL, TIA listings, and other applicable certifications.
   2. Schedule submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for 27xxxx series sections
   3. Shop Drawings submittal, consisting of proposed changes to cable routing, or termination locations/configurations

E. Submittal requirements at closeout:
   1. As-Built Drawings: Submit a set of floor plans and (as appropriate) RCPs showing the location of every complement of cabling with its respective ID – these as-built drawings may be combined with those showing the pathways (cable trays, conduits, etc.). The IDs on the shop drawings shall exactly match the physical labeling applied to cabling components.
   2. Link ID –to– Office Number Key: Submit a "link ID-to-office number key" as an electronic format (such as an MS-Excel spreadsheet file or cloud-based medium) that lists every permanent link associated with the final location / office number.
   3. Crossconnection records/cut sheets
   4. Operations and Maintenance (O&M) Manuals

F. Posted Documentation
1. Post one full size plot of as-built drawings, specifically the floor plans and (as applicable) reflected ceiling plans, within TRs showing each TR's serving area. Coordinate location with Owner.

1.6 QUALITY ASSURANCE

A. Comply with the Quality Assurance requirements of section 270000.

B. Contractor Qualifications
1. In addition to the Contractor Qualifications requirements of section 270000, the Contractor shall be an approved member in good standing of the Leviton Certified Installer network. The Contractor shall maintain a certified RCDD on staff and utilize manufacturer trained, Union certified, or BICSI certified installers.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with the Delivery, Storage and Handling requirements of section 270000.

1.8 WARRANTY

A. Provide to the Owner a Limited Lifetime Product and Performance Warranty covering all components of the horizontal cabling system (cables, jacks, panels, patch cords, equipment, workmanship, etc.). The warranty shall guarantee the cabling system performance to the Category specified herein. Submit a written warranty statement with system documentation. The warranty period shall begin on the system's first use by the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Berk-Tek Leviton Technologies cabling system (no other substitutions allowed)

2.2 SUBSTITUTIONS

A. Comply with the Substitutions requirements of section 270000.

2.3 HORIZONTAL CABLE – CAT6A U/UTP PLENUM RATED (CMP)

A. Application: Suitable for indoor installation, within ceiling space in primary and secondary pathways, within access/raised floor space.

B. Conductors:
1. Insulated Conductors: 23 AWG solid copper, fully insulated with a flame retardant thermoplastic material (material = FEP, or similar).

2. Twisted Pairs: Two insulated conductors “twisted” into a “pair” (twisted pair) color-coded to industry standards (EIA-230).

C. Cable Sheath:
1. Shielding: none
2. Outer Jacket: seamless outer jacket (material = LS-PVC, or similar) applied to and completely cover the internal components (twisted pairs).

D. Flame Rating: CMP, UL listed as such, and the rating shall be printed on the jacket.

E. Electrical and Mechanical Performance: Meet or exceed requirements of TIA-568 standard series, ANSI/ICEA S-116-732, ISO 11801 Class E_A Edition 2.2, and IEEE Std. 802.3an channel for CAT6A cabling.

F. Limited Power: UL certified as “Limited Power (LP)”, and the rating shall be printed on the jacket.
1. Listed to 0.5 A per conductor.

G. Jacket marking: “CMP–LP (0.5A)”

H. Manufacturer:
1. Berk-Tek LANmark-SST CAT6A U/UTP Plenum Rated (CMP) Cable
a. #11101842; CAT6A 4 pair U/UTP cable, CMP, blue

2.4 HORIZONTAL CABLE – CAT6A OSP/UNDERGROUND RATED

A. Application: Suitable for outdoor installation, within underground pathways (conduit, pull boxes) and/or in slab (slab-on-grade).

B. Conductors:
1. Insulated Conductors: 23 AWG solid copper, fully insulated with a thermoplastic material (material = PE, or similar).
2. Twisted Pairs: Two insulated conductors “twisted” into a “pair” (twisted pair) color-coded to industry standards (EIA-230).

C. Cable Sheath:
1. Separator: optional
2. Filled: Cable core (interior to the sheath) shall be flooded with filling compound to protect against moisture penetration. Filling compound: “FLEXGEL”, or similar.
3. Outer Jacket: seamless outer jacket (material = PE, or similar) applied to and completely cover the internal components (twisted pairs), embedded with UV inhibitors, and black in color.

D. Electrical Signal Performance: Meet or exceed TIA-568 standard series, ISO 11801 Class E_A Edition 2.2, and IEEE Std. 802.3an channel requirements for supporting 10GBASE-T.

E. Manufacturer:
1. Berk-Tek
a. #11094458; CAT6A 4 pair U/UTP OSP cable “LANmark-10G” series

2.5 PATCH CORDS – MODULAR, CAT6A U/UTP

A. Application: Suitable for indoor installation within a telecommunications room or workstation environment.

B. Cords shall be factory-assembled from a single, continuous length (no splices permitted) of cordage, homogenous in nature, and terminated at both ends via 8 position modular plugs.

C. Cordage
   1. Insulated Conductors: 26AWG solid andstranded copper, fully insulated with a flame retardant thermoplastic material (such as PVC, or similar).
   2. Twisted Pairs: Two insulated conductors “twisted” into a “pair” (twisted pair), color coded.
   3. Unshielded sheath and flame-retardant polyvinyl chloride (PVC) jacketed.
   4. Flame Rating: CEC CM (or higher) rated, and UL listed as such.

D. Electrical Performance: Meet or exceed TIA-568 standard series and ISO/IEC 11801 requirements for CAT6A cabling.

E. Length: Refer to Outlet Schedule for length requirements.

F. Manufacturer:
   1. Leviton “High-Flex Small OD” Series Patch Cords
      a. #H6A10-03; “High-Flex Small OD” CAT6A modular patch cord, 3 feet
      b. #H6A10-05; “High-Flex Small OD” CAT6A modular patch cord, 5 feet
      c. #H6A10-07; “High-Flex Small OD” CAT6A modular patch cord, 7 feet
      d. #H6A10-10; “High-Flex Small OD” CAT6A modular patch cord, 10 feet
      e. #H6A10-15; “High-Flex Small OD” CAT6A modular patch cord, 15 feet
   2. Leviton CAT 6A Plenum-Rated Patch Cords
      a. #UAPPP-03; CAT6A modular patch cord, 3 feet
      b. #UAPPP-05; CAT6A modular patch cord, 5 feet
      c. #UAPPP-07; CAT6A modular patch cord, 7 feet

2.6 TERMINATION APPARATUS – CAT6A PATCH PANEL, PUNCH DOWN TYPE

A. Application: Panels shall be suitable for installation within a TR for the termination of the horizontal cables specified herein. Panels shall be horizontally oriented for a rack-mounted configuration. Panels shall be capable of supporting, organizing, labeling and patching/crossconnecting between the horizontal termination field and the equipment termination field.

B. Modular patch panel shall have 110-type termination, and shall be compatible with the specified horizontal cables both electrically and physically.

C. Mechanical Performance: Each port shall be an 8-position modular jack, compliant to ANSI/TIA-568.

D. Electrical Performance: Each port shall meet or exceed TIA-568 standard series and ISO/IEC 11801 requirements for CAT6A U/UTP cabling through the cable termination and patch cord connection.

E. Manufacturer:
   1. Leviton 110-Style CAT6A Patch Panels
      a. #6A586-U24; flat modular patch panel, 1U, 24 CAT6A ports

b. #6A586-U48; flat modular patch panel, 2U, 48 CAT6A ports

2.7 TERMINATION APPARATUS – CAT6A MODULAR 8-POSITION CONNECTORS, UNSHIELDED

A. Application: Modular connectors, i.e., jacks and plugs, shall be used for the termination of 4-pair U/UTP cables, and shall be compatible – both electrically and physically – with the cables specified herein.

B. Mechanical Performance: Modular connectors shall be 8-position, compliant to TIA-568 standard series.

C. Electrical Performance: Modular connectors shall meet or exceed TIA-568 standard series and ISO/IEC 11801 requirements for CAT6A U/UTP cabling.

D. Manufacturer:
1. Leviton “Atlas-X1” Series CAT6A Jacks
   a. #6AUJK-RL6; modular 8-position jack, CAT6A, blue
   b. #6AUJK -RW6; modular 8-position jack, CAT6A, white
   c. #6AUJK -RC6; modular 8-position jack, CAT6A, crimson
   d. #6AUJK -RR6; modular 8-position jack, CAT6A, dark red
   e. #6AUJK -RO6; modular 8-position jack, CAT6A, orange
   f. #6AUJK -RY6; modular 8-position jack, CAT6A, yellow
   g. #6AUJK -RV6; modular 8-position jack, CAT6A, green
   h. #6AUJK -RI6; modular 8-position jack, CAT6A, ivory
   i. #6AUJK -RT6; modular 8-position jack, CAT6A, light almond
   j. #6AUJK -RE6; modular 8-position jack, CAT6A, black
   k. #6AUJK -RG6; modular 8-position jack, CAT6A, gray
   l. #6AUJK -RP6; modular 8-position jack, CAT6A, purple
   m. #6AUJK -RB6; modular 8-position jack, CAT6A, brown
2. Leviton “eXtreme” Series CAT6A Jacks
   a. #6110G-RL6; modular 8-position jack, CAT6A, blue
   b. #6110G-RW6; modular 8-position jack, CAT6A, white
   c. #6110G-RC6; modular 8-position jack, CAT6A, crimson
   d. #6110G-RR6; modular 8-position jack, CAT6A, dark red
   e. #6110G-RO6; modular 8-position jack, CAT6A, orange
   f. #6110G-RY6; modular 8-position jack, CAT6A, yellow
   g. #6110G-RV6; modular 8-position jack, CAT6A, green
   h. #6110G-RI6; modular 8-position jack, CAT6A, ivory
   i. #6110G-RT6; modular 8-position jack, CAT6A, light almond
   j. #6110G-RE6; modular 8-position jack, CAT6A, black
   k. #6110G-RG6; modular 8-position jack, CAT6A, gray
   l. #6110G-RP6; modular 8-position jack, CAT6A, purple
   m. #6110G-RB6; modular 8-position jack, CAT6A, brown

2.8 WORK AREA OUTLETS – FLUSH-MOUNT FACEPLATES

A. Application: Faceplates shall be suitable for indoor installation for standard 1-gang and 2-gang flush-mount devices.

B. Faceplates shall have 2, 3, 4, or 6 ports, and shall include required accessories, such as icons, blank inserts, label windows and labels.

C. Color: White

D. Manufacturer:
   1. Leviton “QuickPort” Type, with label windows
      a. #42080-1WS; “QuickPort” faceplate, 1-gang, 1 port, white
      b. #42080-2WS; “QuickPort” faceplate, 1-gang, 2 ports, white
      c. #42080-3WS; “QuickPort” faceplate, 1-gang, 3 ports, white
      d. #42080-4WS; “QuickPort” faceplate, 1-gang, 4 ports, white
      e. #42080-6WS; “QuickPort” faceplate, 1-gang, 6 ports, white

2.9 WORK AREA OUTLETS – FACEPLATES FOR WALL PHONE OUTLETS

A. Application: Faceplates shall be suitable for indoor installation for standard 1-gang flush-mount device equipped with 1 modular jack and two mounting studs for standard wall-mount telephones.

B. Faceplates shall include required accessories, such as icons, blank inserts, label windows and labels.

C. Color: Finish shall be stainless steel.

D. Manufacturer:
   1. Leviton
      a. #4108W-1SP; wall phone faceplate, stainless steel, recessed port
      b. #4108W-0SP; wall phone faceplate, stainless steel

2.10 WORK AREA OUTLETS – FACEPLATES FOR FURNITURE SYSTEMS

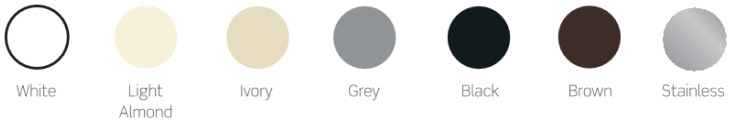
A. Four port faceplates for modular furniture systems that fits into _" x _" opening.

B. Color: White.

C. Manufacturer:
1. Leviton

MODULAR FURNITURE BRACKETS		
[B]	Steelcase Series 9000®, Haworth®, Knoll®, Allsteel®, Westinghouse®, and Teknion®	49222-BLK
[C]	Herman Miller Ethospace® and Steelcase Avenir®	49222-ESP
[D]	Herman Miller Action Office®	49222-HAO

QUICKPORT MODULAR FURNITURE WALLPLATES					
	DESCRIPTION	WHITE	IVORY	GREY	BLACK
	2-Port Standard Depth	49910-SW2	49910-SI2	49910-SG2	49910-SE2
[E]	4-Port Standard Depth with 1 QuickPort Blank	49910-SW4	49910-SI4	49910-SG4	49910-SE4
	4-Port Extended Depth with 1 QuickPort Blank	49910-EW4	49910-EI4	49910-EG4	49910-EE4
	2-Port Herman Miller	49910-HW2	49910-HI2	49910-HG2	49910-HE2
[F]	4-Port Herman Miller with 1 QuickPort Blank	49910-HW4	49910-HI4	49910-HG4	49910-HE4



Standard- and extended-depth wallplates are compatible when used with Herman Miller G1189A Reducer, available from Herman Miller dealers.

a. #49910-SW2; furniture faceplate, standard depth, 2 ports, white

2.11 WORK AREA OUTLETS – <DECORA><DUPLEX 106> JACK FRAME

A. Outlet frame shall be <Decora><duplex 106> style.

B. Color: <White><Black><other>

C. Manufacturer:
1. Leviton
a. #41641-00W; “QuickPort” Decora style frame, 1 port, white
b. #41642-00W; “QuickPort” Decora style frame, 2 ports, white
c. #41643-00W; “QuickPort” Decora style frame, 3 ports, white
d. #41644-00W; “QuickPort” Decora style frame, 4 ports, white
e. #41646-00W; “QuickPort” Decora style frame, 6 ports, white
f. #80401-00W; Decora style coverplate, 1-gang, white
g. #84401-040; Decora style stainless steel coverplate, 1-gang
h. #41641-00T; “QuickPort” Decora style frame, 1 port, light almond
i. #41642-00T; “QuickPort” Decora style frame, 2 ports, light almond
j. #41643-00T; “QuickPort” Decora style frame, 3 ports, light almond
k. #41644-00T; “QuickPort” Decora style frame, 4 ports, light almond
l. #41646-00T; “QuickPort” Decora style frame, 6 ports, light almond
m. #80401-00T; Decora style coverplate, 1-gang, light almond
n. #41641-00I; “QuickPort” Decora style frame, 1 port, ivory
o. #41642-00I; “QuickPort” Decora style frame, 2 ports, ivory
p. #41643-00I; “QuickPort” Decora style frame, 3 ports, ivory
q. #41644-00I; “QuickPort” Decora style frame, 4 ports, ivory
r. #41646-00I; “QuickPort” Decora style frame, 6 ports, ivory
s. #80401-00I; Decora style coverplate, 1-gang, ivory
t. #41641-00E; “QuickPort” Decora style frame, 1 port, black
u. #41642-00E; “QuickPort” Decora style frame, 2 ports, black
v. #41643-00E; “QuickPort” Decora style frame, 3 ports, black

w. #41644-00E; “QuickPort” Decora style frame, 4 ports, black
x. #41646-00E; “QuickPort” Decora style frame, 6 ports, black
y. #80401-00E; Decora style coverplate, 1-gang, black
z. #41641-0GY; “QuickPort” Decora style frame, 1 port, gray
aa. #41642-0GY; “QuickPort” Decora style frame, 2 ports, gray
bb. #41643-0GY; “QuickPort” Decora style frame, 3 ports, gray
cc. #41644-0GY; “QuickPort” Decora style frame, 4 ports, gray
dd. #41646-0GY; “QuickPort” Decora style frame, 6 ports, gray
ee. #80401-0GY; Decora style coverplate, 1-gang, gray
ff. #41087-2WP; “QuickPort” duplex 106 style frame, 2 ports, white
gg. #41087-QWP; “QuickPort” duplex 106 style frame, 4 ports, white
hh. #88003-000; Duplex style coverplate, 1-gang, white
ii. #84003-040; Duplex style stainless steel coverplate, 1-gang
jj. #41087-2TP; “QuickPort” duplex 106 style frame, 2 ports, light almond
kk. #41087-QTP; “QuickPort” duplex 106 style frame, 4 ports, light almond
ll. #78003-000; Duplex style coverplate, 1-gang, light almond
mm. #41087-2IP; “QuickPort” duplex 106 style frame, 2 ports, ivory
nn. #41087-QIP; “QuickPort” duplex 106 style frame, 4 ports, ivory
oo. #86003-000; Duplex style coverplate, 1-gang, ivory
pp. #41087-2EP; “QuickPort” duplex 106 style frame, 2 ports, black
qq. #41087-QEP; “QuickPort” duplex 106 style frame, 4 ports, black
rr. #80703-00E; Duplex style coverplate, 1-gang, black
ss. #41087-2GP; “QuickPort” duplex 106 style frame, 2 ports, gray
tt. #41087-QGP; “QuickPort” duplex 106 style frame, 4 ports, gray
uu. #87003-000; Duplex style coverplate, 1-gang, gray

2.12 WORK AREA OUTLETS – SURFACE OUTLETS

A. Application: Surface outlets shall be suitable for indoor installation for surface-mount device and shall be fully compatible with the specified modular connectors/jacks.

B. Color: White.

C. Manufacturer:
1. Leviton “QuickPort” Series Surface-Mount Boxes
a. #41089-1WP; surface outlet box, 1 port, white
b. #41089-2WP; surface outlet box, 2 ports, white
c. #41089-4WP; surface outlet box, 4 ports, white
d. #41089-6WP; surface outlet box, 6 ports, white

2.13 CONNECTOR ADAPTERS AND BRACKETS

A. Drop Wire Jack/Box Bracket
1. Application: Brackets shall retain and hold in place connectors and attach to a drop wire, such as within a ceiling space; brackets shall be fully compatible with the connectors/connector accessories specified herein.
2. Manufacturer, or equal:
a. Leviton
1) #49223-CBC; QuickPort bracket with clip for drop wire, galvanized
2) #49223-W10; Plenum Rated In-Ceiling Bracket

2.14 LABELS

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels shall be permanent, unless otherwise noted.

C. Cable and Wire Labels
   1. Labels for cables and wires shall be either of the following types:
      a. Tape – adhesive-backed, wrap-around, self-laminating
      b. Strip – adhesive backed, under shrink-wrap
   2. Face stock (print area) shall be white.
   3. Size: as needed per cable size/diameter and to fit the full identifier.
   4. Manufacturer:
      a. Brother P-Touch Labels
         1) #TZeFX241; .75” / 18mm Black on White, Flex Tape – Cable Rapping

D. Patch Panel, Faceplate, and Surface Outlet Labels
   1. Application: For patch panels that do not have an integrated labeling feature and do not come packaged with labeling parts.
   2. Patch panel labels shall be adhesive backed, and shall fit within the area suitable for labeling the ports on the panel.
   3. Face stock (print area) shall be white.
   4. Size: as needed.
   5. Manufacturer:
      a. Brother P-Touch Labels
         1) #TZe221; .35” / 9mm Black on White, Patch Panel and Plates
         2)

2.15 MISCELLANEOUS COMPONENTS

A. Loom Tubing
   1. Application: manage and protect cables from feed point to furniture system, or similar
   2. Manufacturer, or equal:
      a. Panduit
         1) #CLT100F-C20; split corrugated loom tubing (polyethylene), 0.91" ID, black
         2) #CLT125F-L20; split corrugated loom tubing (polyethylene), 1.28" ID, black
         3) #CLT150F-T20; split corrugated loom tubing (polyethylene), 1.58" ID, black
         4) #CLT188F-C20; split corrugated loom tubing (polyethylene), 1.85" ID, black

B. Velcro Cable Ties
   1. Width: .75”.
   2. Color: Velcro cable ties the same color as the cable to which it is being applied.
   3. Manufacturer, or equal:
      a. Panduit “Tak-Ty” series cable ties
      b. Panduit
         1) #HLS-15R0; black, 15’ roll, cut to length

C. Plenum Cable Ties
   1. Application: for use in plenum or air handling spaces
   2. Compliance: AH-2
   3. Manufacturer, or equal:
      a. Panduit “Pan-Ty” PLT series plenum cable ties

b. Panduit
   1) #PLT.65M; Pan-Ty series plenum cable tie, 2.8" (71mm) length / 0.6" diameter bundle
   2) #PLT.7M; Pan-Ty series plenum cable tie, 2.8" (71mm) length / 0.6" diameter bundle
   3) #PLT1M; Pan-Ty series plenum cable tie, 3.9" (99mm) length / 0.87" diameter bundle

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of section 270000.

3.2 EXAMINATION AND PREPARATION

A. Rooms: Prior to installation, verify equipment rooms are suitable to accept the horizontal cables and terminations.

B. Pathways: Prior to installation verify that pathways and supporting devices, provided under other sections, are properly and completely installed (at least the portions into which cables will be placed), and that temporary supports, devices, etc., have been removed. Cable tray shall be complete prior to placing cables within them, per CEC (at least the portions into which cables will be placed). Verify dimensions of pathways, including length (for example, “True Tape” the conduits) to ensure that the resulting cable lengths will not exceed the maximum allowable length specified herein.

C. Cable Integrity: Prior to installation, verify the cable’s integrity – both sheath and conductors. Documentation of pre-installation testing is not a close out requirement, and is the responsibility of the Contractor.

3.3 INSTALLATION

A. Cable Installation and Routing
   1. No cable length shall violate the requirements stated in “System Description”.
   2. Cables shall have continuous sheath continuity. Splices are not permitted anywhere.
   3. Install cables within the cable manufacturer’s published installation temperature range.
   4. Place cables within designated pathways, such as cable tray, cable hangers, etc. Do no fasten (such as with cable ties) or attach cables to other building infrastructure (such as ducts, pipes, conduits, etc.), other systems (such as ceiling support wires, wall studs, etc.), or to the outside of conduits, cable trays, or other non-approved pathway systems.
   5. Place and suspend cables during installation and termination in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation or termination.
   6. In general, route cables at 90-degree angles, along corridors (for improved maintenance and access).
   7. Do not bend cables tighter than 2 inches during and after installation.
   8. Do not exceed manufacturer's limits for pulling tension.
   9. Do not use cable-pulling compounds / pulling lubricants for indoor installations.

10. Route cables under building infrastructure (such as ducts, pipes, conduits, etc.) – to result in easy accessibility to the cables for future maintenance.
11. Place cables at least 6 inches away from power sources – to reduce interference from EMI.
12. Neatly dress and organize cables using designated cable routing facilities, and fasten to support devices via Velcro-type straps.
13. When exiting primary pathways (such as cable tray) to the work area, exit via the top of the pathway.
14. Cable Ties: Install cables ties, where allowed, tight enough to keep cables organized/managed but loose enough to be moved about the cables/cable bundles. Cable ties shall not deform or cinch cables too tightly. Tie installed too tightly per the Engineer's opinion shall be subject to removal upon direction from the Engineer.

B. Cable Routing and Dressing within the TR
1. Place cables within the overhead cable support. When routing vertically, fasten the cables onto vertical cable support approximately every 24 inches using approved cable fastening means.
2. At the rack bay, route cables within the back of the vertical management sections (do not route cables into the front as this space is reserved for patch cords only). Divide the cables equally between both sides of an equipment rack such that a cable does not travel past the midpoint of the rack prior to termination. Dress and cut cables to length required to reach the designated termination point (maintaining bend restrictions) with no excess cable slack left in the horizontal cable manager (if used) and vertical management section.
3. < Do not provide slack within the TR. >–or–< Provide 10-15 feet, minimum, sheathed cable slack – length not to exceed permanent link maximum length requirement. Place the slack <in the overhead cable support><under the raised floor>. >

C. Termination in the TR
1. Install and assemble termination apparatus, accessories and associated management apparatus according to the manufacturer's instructions.
2. Properly strain relieve cables at termination points per manufacturer's instructions.
3. For OSP cables, apply sealant (such as B-sealant) where the pairs exit the cable jacket to seal the end of the cable and prevent water-blocking gel from leaking from the cable's sheath.
4. Terminate cables and twisted pairs in accordance with manufacturer's latest installation requirements and TIA-568 series standard installation practices. Terminate cable pairs onto the termination apparatus. Terminate twisted pairs compliant to TIA-568 series standards and wired per 1.04 System Description.
5. Patch Panels and Horizontal Management Panels
    a. Quantity: Provide patch panels to support termination of cables. Provide horizontal management panels based on the quantity of patch panels.
    b. Install and assemble discrete port patch panels and horizontal management panels according to the manufacturer's instructions.
    c. Install the patch panels and the horizontal management panels as shown on the contract drawings. If configuration is not shown, install the patch panels in association with the horizontal management panels such that a management panel is mounted above and below given patch panel.
6. Termination Sequence
    a. Terminate the cables in sequential order using the link's identifier starting at the top left and completing a panel before moving to the next panel below.

D. Cable Routing and Dressing at the Work Areas
   1. Leave 2-4 feet sheathed cable slack – length not to exceed permanent link maximum length requirement. Store slack within ceiling space neatly on a cable hanger.
   2. Routing to Type “B” Furniture-Mount Faceplates
      a. While placing cables into furniture, exercise caution to prevent scraping, cutting, or other damage to cable’s jacket.
      b. Provide spiral wrap around cables from furniture-feed pathway (such as a wall feed to the point where cables enter furniture.

E. Termination at the Work Areas
   1. Mount faceplates plumb, square, and at the same level as adjacent device faceplates.
   2. Patch gaps around faceplates so that faceplate covers the entire opening.
   3. Terminate cables and twisted pairs in accordance with manufacturer's latest installation requirements and TIA-568 series standard installation practices and wired per 1.04 System Description.

F. Perform post-installation testing as described in the Telecommunication Testing specification (refer to section 270811). Replace permanent links (cables, terminations and connectors) not passing the required tests.

G. Patching and Crossconnecting
   1. In IDFs, provide modular patch cords as shown on contract drawings for network service. If not shown, provide one modular patch cord per complement/device; install between the network switch and the horizontal field. Neatly dress patch cords within the horizontal and vertical management components. Store cord slack within the vertical management section.

3.4 LABELING

A. General Requirements
   1. Labeling, identifier assignment, and label colors shall conform to the TIA-606 standard and as approved by the Owner before installation.
   2. Label text shall be machine-generated; hand written labels will not be accepted.

B. Label Formats and Text Attributes
   1. Horizontal Cable Labels
      a. Labels for cables shall be wrap-around self-laminating type.
      b. Labels shall be permanent.
      c. Text Attributes: color: black; size: approx. 1/8” high (#12 font size).
   2. Termination Field \ Patch Panel Labels
      a. Labels for cables shall be adhesive-backed polyester (or similar) type.
      b. Label color shall be white.
      c. Text Attributes: color: black; size: approx. .35” high
   3. Termination Field \ Termination Block Labels
      a. Use labels included in the block kit packaging. Any deviation from this requirement must be approved in writing by the Owner
      b. Label color shall be white.
      c. Text Attributes: color: black; size: approx. .50” high.
   4. Outlet Labels
      a. Labels for cables shall be adhesive-backed polyester (or similar) type.
      b. Label color shall be white.
      c. Text Attributes: color: black; size: approx. .35” high.

5. Outlet Port Labels
    a. (These labels are in the case that the faceplate/surface outlet does not have port numbers stenciled or molded into the product.)
    b. Labels for cables shall be adhesive-backed polyester (or similar) type.
    c. Label color shall be white.
    d. Text Attributes: color: black; size: approx. .35” high.

C. Identifier System
1. General: Separate fields of the identifier with a hyphen.
2. Individual Ports at Patch Panels
    a. First field: the end user room number; for example: “D107”.
    b. Second field: outlet port number, for example “D1”.
    c. Example: “D107-D1”
3. Outlets (Faceplates, Surface Outlets, etc.)
    a. First field: the originating BDF/IDF room number; for example: “AD1.1”.
    b. Second field: the destination room number; for example: “D107”.
    c. Third field: a unique sequential number; for example: “01”.
    d. Example: “AD1.1-D107-01”
4. Individual Ports at the Outlets
    a. The specified faceplate has individual port numbers molded into the product. However, if a substitution is accepted that does not have port numbers, provide port labels as follows.
    b. First field: the cables intended service type followed by a unique sequential number, for example “D1”.
5. Horizontal Cables
    a. First field: the originating BDF/IDF room identity; for example: “AD1.1”.
    b. Second field: the destination room number; for example: “D107”.
    c. Third field: a unique sequential outlet number, for example “01”.
    d. Fourth field: a unique port number, for example “D1”.
    e. Fifth field: the cable type; for example: “CAT6A”
    f. Example: “AD1.1-D107-01-D1-CAT6A”

D. Label Installation
1. Horizontal Cable Labels
    a. Install labels on both ends of cables no more than 4" from the edge of the cable jacket.
    b. Install labels such that they are visible during normal maintenance.
2. Termination Group\Patch panel ports
    a. Install labels on the front and on left side.
    b. Install labels such that they are visible during normal maintenance.
3. Termination Port\Patch panel ports
    a. If the patch panel does not have individual port numbers stenciled on the product, then install port labels at each port – above the top row and below the bottom row.
4. Outlet Labels
    a. Install label in the top label window. Leave the bottom label window blank.
5. Outlet Port Labels
    a. If the outlet does not have individual port numbers stenciled or molded into the product, then install port labels at each port – either to the sides (preferred) or above the top row and below the bottom row.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the work of this section compliant to the requirements of section 270000.

B. Remove cables and replace with new without impact to cost and schedule those failing to meet the indicated standards and not passing the testing requirements of section 270811. The Owner will not accept the installation until testing has indicated a 100% availability of cables and conductors. Any deviation from this requirement must be approved in writing by the Owner.

C. Comply with system acceptance and certification requirements of section 270000.

END OF SECTION 27 15 13

SECTION 27 41 16

INTEGRATED AUDIOVISUAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Audiovisual systems – presentation systems, conference systems, distributed audio systems distributed video systems, control systems, and interface with other systems. Refer to article 1.4 “System Description” for more information.

B. Base Bid Work
   1. Provide equipment and materials, whether specifically mentioned herein or not, needed for a complete and operating audiovisual systems to satisfy the requirements of this section and related drawings. This specification lists major equipment but not every wire, connector, extender, converter, fastener, etc., needed to complete the work.
   2. Equipment racks or enclosures:
      a. Plenum enclosures: Provide plenum-rated equipment enclosures, including frame, side panels, top panels, access doors, anchorage and seismic bracing, integrated power outlets and cooling provisions as required.
      b. Provide standard or custom accessories and mount adapters for equipment installed in equipment racks or enclosures as needed to properly mount equipment, power supplies, accessories, components, and the like. Provide cable management to properly route and mind wires, cables, and cords.
      c. Provide power receptacle strips in quantities needed to supply power to the equipment within the rack.
      d. Provide spare rack mounting screws. Determine based on rack mount units (RUs) – 1 spare screw per 2 RU installed, minimum.
      e. Provide bonding for racks, cabinets, equipment, equipment support and cable/wire management to an approved grounding point.
   3. Cooling provisions
      a. Provide cooling provisions (means to move heat out of enclosed spaces to prevent temperatures from exceeding equipment manufacturer’s specified maximums). Ensure equipment operates within manufacturer’s cooling guidelines. Provide only code-compliant cooling provisions (e.g., exhausting from one space to another).
      b. In racks, enclosures, millwork, cabinets, and other spaces where equipment will be installed and prone to heat buildup, provide thermostatically-controlled active cooling devices to create adequate airflow through the enclosed space. Examples of active cooling devices include vent fans. At a minimum, ensure airflow by installing active cooling devices or systems such as fans.
   4. Provide power controllers (such as an IP power strip connected to the network or controllable through the room control system) to devices that cannot inherently be remotely controlled for power cycling. Verify functional operation for specified control operations.
   5. Provide audio transformers, whether or not explicitly shown on the drawings, with appropriate impedance ratios and power handling capacities as required for the intended function of the System.
   6. Provide networks and pads, whether or not explicitly shown on the drawings, as required to achieve proper impedance matching and levels. Provide networks and pads that are balanced and constructed from 0.5 watt, 5% resistors, soldered to fixed connection points at each end.

7. Labeling: Provide labeling for audiovisual system components. The components include, but are not limited to, the following:
    a. Equipment racks and equipment enclosures
    b. Rack-mounted equipment and devices: Provide a label on the back of each piece of equipment. If a serial number (of a given piece of equipment) is not visible in a final installed condition, provide a label on the equipment on a visible location duplicating the serial number.
    c. Wall-mounted equipment and devices: Provide an equipment label on the back of each piece of equipment. If a serial number (of a given piece of equipment) is not visible in a final installed condition, provide a label on the equipment on a visible location duplicating the serial number.
    d. Provide an equipment plate for each piece of equipment.
    e. Provide a label for each control that is not inherently labeled, such as those in racks and user spaces.
    f. Wires and cables: Provide a cable label at each end of each piece of wire, cable and cord.
    g. Terminal blocks, patch panels, and other termination apparatus: Provide a label on each termination block, piece of termination apparatus and termination position on patch panels.
    h. Handheld, lavalier, wireless, and other microphones and associated equipment (such as receivers)
    i. User interface devices/plates
8. Coordination Requirements
    a. Coordinate with the construction team at large to ensure that equipment and other system components will be installed properly, and that there will be no compromises due to, among other aspects, spatial conflicts or power service incompatibilities.
    b. Coordinate with the electrical contractor for power requirements and service connection to the System's equipment.
    c. Coordinate with the telecom contractor and other trades/contractors (as needed) placement of cables and wires when sharing pathways (such as cable tray) with other low voltage systems. Do not place cables and wires into pathways provided by others without permission.
    d. Coordinate with the telecom contractor (or Owner) for locations within racks for installing equipment"
    e. Coordinate with the Owner (or Owner's network provider) for network configurations and/or settings required for the System's proper or correct operation.

C. Related Divisions and Sections: Consult other divisions, determine the extent and character of related work. Coordinate the work of this section with, at least but not limited to, the following divisions and sections:
1. Division 0 (for Bidding Requirements, Contract Forms, and Conditions of Contract) and Division 1 (for General Requirements) – provisions listed or specified therein apply to work under this section.
2. Section 270000, "Communications Basic Requirements"
3. Division 26, "Electrical Systems"
4. Division 23, "Heating, Ventilating, and Air Conditioning Systems"
5. Section 271513, "Communications Horizontal Cabling"
6. Section 270811, "Communications Twisted Pair Testing"
7. Section 270821, "Communications Fiber Optic Testing"

D. Products Installed but not Furnished Under this Section
1. Owner-furnished equipment
2. Network patch cords

E. Products Specified but not Installed Under this Section
   1. Room scheduling displays

F. Products Furnished and Installed Under Another Section
   1. Rough-in (device boxes, conduits, and related accessories)
   2. Electrical service (e.g., 120 VAC); refer to division 26
   3. Telecommunication cabling; refer to section 271513
   4. Telecommunication pathways; refer to section 270528.
   5. Network switches, with Power over Ethernet (PoE)

1.2 REFERENCES

A. Comply with the References requirements of section 270000.

B. In additional to the references listed in section 270000, perform work in accordance with applicable requirements of governing codes, rules and regulations including the following minimum standards, whether statutory or not:
   1. National Fire Protection Agency (NFPA)
      a. NFPA 262, “Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces”
   2. Underwriters Laboratories (UL)
      a. UL 969, “Marking and Labeling Systems”
      b. UL 1419, “Professional Video and Audio Equipment”
      c. UL 60065, “Audio, Video and Similar Electronic Apparatus – Safety Requirements”
   3. AVIXA
      a. A102.01, “Audio Coverage Uniformity in Listener Areas”
      b. ANSI/AVIXA D401.01:201X “Standard Guide for AV Systems Design and Coordination Processes”
      c. V201.01:2018, “Projected Image System Contrast Ratio”
      d. F501 01, “Cable Labeling for Audiovisual Systems”
   4. “Sound Systems Engineering”, 3rd Ed., Davis and Davis
   5. Electronic Components Industry Association (ECIA)
      a. EIA/ECA-310, “Cabinets, Racks, Panels, and Associated Equipment”

1.3 DEFINITIONS

A. Refer to section 270000 for definitions. The definitions of section 270000 apply to this section.

B. In addition to those definitions of section 270000 and Division 01, the following terms used in this specification are defined as follows:
   1. “ACEG”: alternating current equipment ground (an example of this is a ground bus within an electrical panel)
   2. “Approved Grounding Point”: an approved grounding point is one that satisfies the applicable electrical code and provides a low impedance path to earth. Examples include the following though may manifest in different means: a telecommunications grounding busbar (such as for bonding an equipment rack within a telecom room), the ACEG of the electrical panel serving the equipment requiring bonding to ground (such as for bonding a credenza rack within a conference room), or the ground conductor of a branch circuit (such as for bonding a single piece of equipment).
   3. “A/R”: Indicates that the quantity of an item is as required to meet the design criteria indicated in the audiovisual drawings and specifications.
   4. “A/S”: Indicates that the quantity of an item is as shown on the drawings.

5. “Audience Area”: the portion of a presentation space intended to be occupied by an audience. An audience area includes the primary seating and standing spaces and may include the adjacent circulation spaces. An audience area generally excludes spaces reserved for presenters.
6. “Custom” indicates systems or components the Contractor fabricates based on these specifications and drawings
7. “EDID”: Extended display identification data
8. “HDCP”: High-bandwidth digital content protection
9. “HDMI”: High-definition multimedia interface
10. “OFE”: Owner Furnished Equipment
11. “Or equal” indicates an item that is equal in function and performance to the specified device or system
12. “RU”: rack unit, as defined in EIA/ECA-310
13. “Shall” denotes a mandatory requirement
14. “Should” denotes an advisory statement
15. “SPL”: sound pressure level
16. “THD”: total harmonic distortion
17. “Will” denotes an informative statement
18. “Project”: The scope of work defined by this specification and its related drawings
19. “Software”: Any executable programs, parameter files, user interfaces, or other coded content that are required to operate, control, or maintain the audiovisual systems in this Project
20. “Custom Created Software”: Any software, parameter files, user interfaces, or other coded content created for the control or operation of the audiovisual systems in this Project
21. “Third-party software:” Any programming developed by a party other than the AV Contractor and the Owner to be used to operate, control, or maintain the audiovisual systems in this Project
22. “System”: The audiovisual components, cabling, and programming incorporated in the descriptions and equipment lists herein

1.4 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS

A. General
1. In circumstances where the specifications and drawings conflict, the drawings govern quantity and the specifications govern quality.
2. The contract drawings and specifications convey design intent. They are not intended to be used in lieu of shop drawings.

B. ADA Compliance: Provide the following:
1. Display of closed captioning content
2. Accessible control systems
3. Assistive listening systems

C. Audio System Performance Criteria
1. Provide echo cancellation for microphones in audio and video conferencing systems.
2. Frequency Response:
   a. Program audio system: 100 Hz to 12,000 Hz. 3 dB per octave roll off below 100Hz and above 12 kHz.
   b. Distributed audio system: 125 Hz to 10,000 Hz. 3 dB per octave roll-off below 125 Hz and above 10 kHz.
3. Total Acoustical Harmonic Distortion:
   a. Program audio system: less than 2% at 90 dBC (1 kHz reference) at four feet (1,220 mm) above finished floor in the middle of the room.

b. Distributed audio system: less than 2% at 85 dBC (1 kHz reference) at four feet (1,220 mm) above finished floor in the middle of the room.

4. Signal to noise ratio (mixer input to amplifier output): 75 dB from 50 Hz to 15 kHz minimum.
5. Frequency response with equalizers bypassed: less than ±1 dB from 50 Hz to 12 kHz.
6. Distortion: less than 0.5% at 1 kHz at the equipment's rated input signal level.
7. Output levels (in audience areas without objectionable distortion, rattles, or buzzes, employing as test signals several different samples of recorded music and microphones applied at each system input):
   a. Program audio: not less than 95 dB
   b. Speech reinforcement: not less than 85 dB
8. Hum and Noise: inaudible (below the background noise level of the space) under normal operation observed in audience areas.

D. Video System Resolutions
1. System component minimum resolution: capability of 1920 X 1080.
2. Supported resolutions: 1,280 x 720, 1,920 x 1,080, 1,920 x 1,200, 3840 X 2160, and 4096 x 2160.

E. Wireless Systems
1. Ensure that wireless AV systems do not create radio frequency interference to other systems.
2. Demonstrate at AV acceptance testing that wireless AV systems are not adversely affected by AV-related nor other radio frequency sources.

F. Control Systems
1. Provide user interfaces, such as control panels, that respect ergonomics and varying levels of technical ability among users. Follow these guidelines:
   a. Avoid abbreviations
   b. Size lettering at 1/8" minimum
   c. Maintain background to lettering contrast
2. Positive logic: Avoid conditions which may cause command synchronization conflicts (i.e., alternate action (toggling) on/off without power reset of feedback. Provide power sensors or other devices where necessary to ensure that positive logic conditions are maintained.
3. Timing: Prevent two or more commands being sent simultaneously to the same piece of equipment.
4. Linking: Provide linking of functions to require the fewest number of user actions to effectively control the equipment.
5. Clearing: Ensure that each media selection clears the previous audio and visual selection (e.g., selecting COMPUTER clears the audio and video section of the previous Blu-ray disk selection).
6. Defaults: Establish default power-up conditions for the system including device audio levels, warm-up routine, power conditions, switcher status and other default conditions as required by the Owner or the Owner's representative.
7. Volume Memory: Provide easy-to-use memory for volume settings associated with each source device. Unless directed otherwise in this document, provide programming that maintains these settings between alternate selections during each use – through power-on and power-off.
8. Status indication: Program buttons for both touch panels and pushbutton panels to provide clear status indication using illumination when back-lighting is available or by changing color.
9. Failsafe: Provide program that ensures that no operation or sequence of operations causes the control system to become inoperable or interferes with further processing, correct operations or execution of commands.

G. Centralized Management Procedure
   1. Provide server-based software for the management of the AV systems deployed in the facility and the District. Include the following:
      a. Help-desk functionality
      b. Enterprise-wide scheduling and monitoring
      c. Time-stamped AV systems data collection for reporting

H. Room Types

I. General
   1. The audiovisual systems design and documentation in this set of contract documents are based on standard room types.
   2. Each room to receive audiovisual systems is shown on the drawings with a type designation.
   3. For each room, adapt the audiovisual system to best suit the architectural layout such that each room of a certain type is similar to others of its type, with minor layout differences to accommodate architecture.
   4. Refer to the drawings for the quantities of each type of room and for specific audiovisual interface information per room.

J. Group Study Rooms
   1. Group Study rooms include three sizes: small, medium, and large. These spaces will be used by student and faculty members for meetings and working sessions.
   2. Provide a wall-mounted display for users to share content from personal devices. The required display size for each room type related to the overall room dimensions and sightlines.
   3. Provide hardwired, HDMI laptop connection to the display.
   4. Provide a soundbar in the small and medium rooms for program audio. Provide ceiling-mounted loudspeakers in the large room for program audio.
   5. Provide an Assistive Listening System to meet Code requirements.
   6. Provide a wall-mounted button panel for system control including on/off, volume up/down, and source selection.

K. Meeting Rooms
   1. Meeting rooms are available for faculty member meetings and include software-based video conferencing system. These spaces will support audiovisual presentations and collaboration. Provide a scaled input to the display.
   2. Provide a wall-mounted display for users to share content from personal devices.
   3. Provide hardwired, HDMI laptop connection to the display.
   4. Provide wall-mounted camera and microphone for software-based video conferencing.
   5. Provide ceiling-mounted loudspeakers for program audio.
   6. Provide an RF Assistive Listening System to meet Code requirements.
   7. Provide a wall-mounted control panel for system control including on/off, volume up/down, and source selection.

L. Office of IT Director
   1. The Office of the IT Director is a private office with a basic AV system.
   2. Provide a wall-mounted, annotative display for users to share content from personal devices.
   3. Provide hardwired, HDMI laptop and USB connections to the display.

M. Standard Classroom Type 1
   1. This classroom type is flexible in configuration, has dual projection, extended desktop capabilities.

2. Provide dual projection systems with projectors and projection screens. One projector displays the main output of the instructor's laptop and the second projector displays the extended desktop of the laptop
3. Provide two technology connection points at the front of the room for an instructor lectern containing:
    a. Connection for laptop, including HDMI with multiple adaptors for DisplayPort, Mini DisplayPort and VGA for legacy support including audio
    b. Document camera
4. Provide portable device sharing capability (BYOD)
5. Provide supporting AV presentation system, including switching and amplification functions
6. Provide ceiling-mounted loudspeakers
7. Provide a control system, self-contained, with push-button style panel, to control all functions of the AV systems
8. Provide an Assistive Listening System as required by Code

N. Standard Classroom Type 2
1. Standard Classroom type 2 has fixed seating configuration, dual projection systems with projector and projection screen, with both projectors displaying the main output of the instructor's laptop Dual projector (mirrored image).
2. Provide projectors and projection screens.
3. Provide a technology connection point at the front of the room for an instructor lectern containing:
    a. Connection for laptop, including HDMI with multiple adaptors for DisplayPort, Mini DisplayPort and VGA for legacy support including audio
    b. Document camera
4. Provide portable device sharing capability (BYOD)
5. Provide supporting AV presentation system, including switching and amplification functions
6. Provide ceiling-mounted loudspeakers
7. Provide a control system, self-contained, with push-button style panel, to control all functions of the AV systems
8. Provide an Assistive Listening System as required by Code

O. Standard Classroom Type 3
1. Standard classroom type 3 has fixed seating configuration, single projection system with projector and projection screen, with the projector displaying the main output of the instructor's laptop.
2. Provide one projector and screen
3. Provide a technology connection point at the front of the room for an instructor lectern containing:
    a. Connection for laptop, including HDMI with multiple adaptors for DisplayPort, Mini DisplayPort and VGA for legacy support including audio
    b. Document camera
4. Provide portable device sharing capability (BYOD)
5. Provide supporting AV presentation system, including switching and amplification functions
6. Provide wall-mounted loudspeakers
7. Provide a control system, self-contained, with push-button style panel, to control all functions of the AV systems
8. Provide an Assistive Listening System as required by Code

P. Standard Classroom Type 4
1. Classroom type 4 is flexible in configuration with a single projection system (projector and projection screen). The projector displays the main output of the instructor's laptop

2. Provide projector and projection screen
3. Provide a technology connection point at the front of the room for an instructor lectern containing:
    a. Connection for laptop, including HDMI with multiple adaptors for DisplayPort, Mini DisplayPort and VGA for legacy support including audio
    b. Document camera
4. Provide portable device sharing capability (BYOD)
5. Provide supporting AV presentation system, including switching and amplification functions
6. Provide ceiling-mounted loudspeakers
7. Provide a control system, self-contained, with push-button style panel, to control all functions of the AV systems
8. Provide an Assistive Listening System as required by Code

Q. Writing Center lab
1. Furnish one digital signage display

R. Library Reading Open Area
1. Library Reading area is flexible space with a single projection system (projector and projection screen). The projector displays the main output of the instructor's laptop
2. Provide projector and projection screen
3. Provide a technology connection point at the front of the room for an instructor lectern containing:
    a. Connection for laptop, including HDMI with multiple adaptors for DisplayPort, Mini DisplayPort and VGA for legacy support including audio
    b. Document camera
4. Provide portable device sharing capability (BYOD)
5. Provide supporting AV presentation system, including switching and amplification functions
6. Provide ceiling-mounted loudspeakers
7. Provide a control system, self-contained, with push-button style panel, to control all functions of the AV systems
8. Provide an Assistive Listening System as required by Code

S. Room scheduling
1. Provide a infrastructure for future room scheduling device outside all AV-enabled rooms to display room reservation information and the room's occupancy status.
2. Each room scheduler will require a single network/data drop.

T. Digital Signage
1. Provide wall-mounted video displays and signage players at each location. Digital signage content will be managed on a cloud-based platform.

1.5 SUBMITTALS

A. Comply with the Submittal requirements of section 270000.

B. Bid Submittal: Submit bids in accordance with the project's overall bidding requirements, and include the following requirements of this section.
1. Site visit: As possible, visit the site before submitting your bid. Coordinate site visit arrangements with the General Contractor. Include date of site visit in the bid submittal.

2. Firm information and qualifications: Include detailed information about the firm, including but not limited to the following, in the bid:
    a. Firm's history – how long the firm has been in business, how long the firm has offered audiovisual systems integration services, etc.
    b. Annual revenue for the three most current years
    c. Bonding capacity and bonding insurance agent contact information
    d. Three successfully completed projects of similar scope within the past 24 months. For each project, include the owner/client name, contact information (person's name, position, and telephone number or email address), project location, type of systems installed, total contract amount, date completed, and services included (e.g., engineering, installation, integration, maintenance, etc.).
    e. Industry affiliations
    f. Advanced certifications (CTS-I/D, DMC-D/E, ACE-D/I/P/RMS, XTP, etc.)
    g. Manufacturer certifications
    h. Contractor license number for the state where the work will take place
    i. Union affiliation(s)
3. Personnel and Certifications: Include information on key personnel in the bid.
    a. Include résumés and certifications for personnel who will be assigned to the project including but not limited to the Project Manager, Systems Engineer, Field Installation Supervisor, Lead Control System Programmer, and other key personnel.
    b. Include résumé(s) of CTS-I (Certified Technology Specialist – Installation) certified personnel
    c. Include résumé(s) of Extron Certified Professionals.
    d. Include other relevant company-held industry, manufacturer, and educational certifications and designations for involved personnel
4. Subcontract Information: Indicate in the bid, all subcontractors and their responsibilities and qualifications.
5. Schedule of Values: Include a schedule of values in the bid. Break out the schedule of values into three areas – equipment costs, non-equipment costs, and service contract.
    a. Equipment Costs: List equipment costs (each piece of equipment), including required modifications and accessories.
    b. Non-equipment Costs: List non-equipment costs, such as the following:
        1) General and Administrative: shipping, insurance, and guarantees, etc.
        2) Fees: e-Waste/disposal, permits, etc.
        3) Engineering: design, drawings, run sheets, instruction manuals, etc.
        4) Pre-installation: fabrication, modification, assembly, rack wiring, etc.
        5) Installation: installation, coordination, supervision, testing, etc.
        6) Owner training: training session(s), manuals, etc.
6. Alternates/Substitutions: Refer to section 270000 for alternate and substitution requirements. Submit bids based on the specified equipment. If the bid includes proposed alternates and/or substitutes, separate these from the costs of the equipment as specified and include for alternate equipment full technical information and cut sheets. Proposed alternate equipment will receive consideration if the differences between the specified and alternate/substituted equipment do not depart from the design intent and function of the system and are in the best interests of the Owner. If the inclusion of substituted equipment will result in a different connection configuration than that in the bid documents, include drawings that illustrate how the proposed system would be connected.
7. System Enhancements: Include in the bid recommendations, if any, that will enhance the performance and/or functionality of the system or will reduce costs without loss of performance/functionality. Recommendations that are of value to the Owner will be taken into consideration in the evaluation of the bids. Make such proposed recommendations as "alternates", with the appropriate cost modifications shown separate and apart from the costs of the system "as specified".

8. Exceptions: In the bid, explain exceptions, if any, to these specifications and related drawings. In the absence of exceptions, these specifications and related drawings are binding in letter and intent.
9. Guarantee compliance with requirements and regulations in effect on the job site. Explicitly state any such non-compliances or conflicts in the bid submittal. The bidder has the responsibility to investigate potential contract, union, and scheduling issues, and to notify the general contractor of such.

C. Pre-construction Submittals
1. Product Data: Prior to purchase and installation, submit as a PDF file information (such as cut sheets, etc.) for equipment, components, products, etc., that will be installed as part of the work of this section.
   a. Include in the submittal, a Table of Contents, listing equipment, components, products, etc., by room, by system, and/or by other logical designation. A continuous list of all products with no reference to where the products will be installed will be rejected. Incomplete lists will be rejected.
   b. Indicate (arrow, highlight or other designator) on each product's cut sheet the manufacturer, model/part number, accessories (as applicable), options (as applicable), color (as applicable), and other information to indicate the exact item to be installed. Where this information is not already provided on the cut sheet, manually input this information and a brief description (as applicable).
2. Substitutions [refer to section 270000 for substitution requirements]: Submit substitution requests based on the specified equipment and including associated equipment costs separate from the costs of the equipment as specified.
   a. Proposals for alternate equipment will receive consideration if the differences between the specified and alternate/substituted equipment do not depart from the overall intent of the design and operation of the system and are in the best interests of the Owner.
   b. Include full technical information and cut sheets for the proposed substitutions.
   c. If the inclusion of substituted equipment will result in a different connection configuration than that in the bid documents, produce drawings that illustrate how the proposed system would be connected.
3. Shop Drawings [refer to section 270000 for additional shop drawing requirements]: Submit shop drawings prior to installation and in accordance with the Conditions of Contract and Division 1, including the following.
   a. Functional line diagrams for all systems – clearly tag each item with name, manufacturer, and manufacturer's model number (e.g., "Program Amplifier LabGruppen LUCIA 60/2M") and show the terminal number or input/output designation (e.g., "Mic 1-In", or "Record Out-Left").
   b. Provide schematic diagrams of custom circuitry such as receptacle pin numbers and component callouts; show details of custom resistive attenuation and/or combining networks, filters, or pads which may be required in the assembly; show point to point wiring drawings for control system modules and interfaces, and for switches and relays in audio, video, or control systems
   c. Equipment rack elevations and patch panel assignments – clearly and consistently label rack elevations, patch panels, and on equipment controls.
   d. Provide pushbutton and handheld remote control panel layouts –tag each button with function and ID matching installed labels
   e. Factory and custom panels, plates, and designation strips, showing material, finish, color and engraving (exact lettering)
   f. Custom designed consoles, tables, carts, support bases, and shelves
   g. Equipment modifications (if any), including details of modifications that change or void manufacturers' warranties.
   h. Cable run lists – clearly show at each terminal point the type of connector to be used; include typical wiring details of each connector; note where shields are

connected and where they will float to ensure the integrity of the shielding system; indicate cable types and, where appropriate, color codes; assign wire numbers and patch bay locations to every wire and patch point in the drawing

i. Wattage tap setting per loudspeaker.

4. User Interface Menu Submittal:
   a. Provide a PDF per system containing a page for each menu, submenu, and popup in that system's user interfaces. Include menus that are manually triggered and those that automatically appear as the result of events such as the connection of a source device. Ensure that the PDF is unlocked so that the Engineer may annotate it.
   b. If the development environment allows, provide an executable menu simulation file or web link for control systems in addition to a PDF-based submittal.
5. Network Coordination: Submit as an Excel file or cloud-based collaborative spreadsheet (such as Google Sheets) a list of equipment that will be connected to the network, including but not limited to the following (e.g., spreadsheet column headers):
   a. Item number
   b. Description
   c. Manufacturer
   d. Model/part number
   e. MAC address
   f. IP address type (DHCP or static)
   g. Power-over-Ethernet (PoE) requirements (yes or no)
   h. Specific network and/or subnet configuration requirements
   i. Specific QOS requirements
   j. Anticipated network traffic
6. Samples: Submit sample panels, plates, and designation strips, including details relating to terminology, engraving, finish and color.
7. Testing Equipment and Procedures:
   a. Submit a list of test equipment, including manufacturer, model number, and description that will be used for testing and adjustment of the installed systems.
   b. Submit testing procedures to be performed during pre-functional testing and acceptance testing, including the minimum acceptable outcome for each test.

D. At the Completion of the Installation
   1. Initial Testing and Tuning Report: After completing initial testing and tuning, checkout, settings, as-built drawings, and operational documentation, submit written notification to the Owner and Architect that initial checkout is complete. Include in this notification a completed Initial Testing and Tuning Report that satisfies the requirements of Part 3. In the Report, document the results for tests performed during initial testing and tuning. Organize the report per room, per system, and per test. Include the testing tools/equipment, manual and automated tests, testing procedures, and expected result per test. If the test equipment stores test results and has the capability to produce reports, also include these reports.
   2. Wireless Microphone Frequencies: Submit a list of wireless microphone frequencies and associated channels used for each microphone and system.

E. Closeout Submittals
   1. Acceptance Testing Report: After completing final acceptance testing, final tuning and settings, submit an Acceptance Testing Report that documents the results for tests performed during final testing and tuning. Organize the report per room, per system, and per test. Include the testing tools/equipment, manual and automated tests, testing procedures, and expected result per test. If the test equipment stores test results and has the capability to produce reports, also include these reports. Include the system's normal settings.

2. As-built Drawings [refer to section 270000 for additional as-built drawing requirements]: Submit as-built drawings in accordance with the Conditions of Contract and Division 1, including the following.
    a. System functional line drawings for all systems; clearly tag each item with name, manufacturer, and manufacturer's model number (e.g., “Program Amplifier LabGruppen LUCIA 60/2M”) and show the terminal number or input/output designation (e.g., “Mic 1-In”, or “Record Out-Left”).
    b. Point-to-point wiring diagrams for switches and relays in audio, video, and control systems; point-to-point wiring diagram for control system modules and interfaces
    c. Schematic diagrams of custom circuitry such as receptacle pin numbers and component callouts; show details of custom resistive attenuation and/or combining networks, filters, or pads which may be required in the assembly
    d. Equipment rack elevations and patch panel assignment drawings. Clearly label the rack elevations, patch panels, and equipment controls.
    e. Cable run lists – clearly show at each terminal point the type of connector to be used; include typical wiring details of each connector; note where shields are connected and where they will float to ensure the integrity of the shielding system; indicate cable types and, where appropriate, color codes; assign wire numbers and patch bay locations to every wire and patch point in the drawing
    f. Pushbutton and handheld remote-control panel layouts, including tagging each button with function and ID that matches installed labels
    g. Factory and custom panels, plates, and designation strips, showing material, finish, color and engraving (exact lettering)
    h. Wattage tap setting per loudspeaker.
3. System Operation and Maintenance (O&M) Manual:
    a. Describe typical procedures necessary to activate each system for full functionality as required under the System Description.
    b. Describe normal settings for equalizer, amplifier, signal processing, and user operated controls (as established during system check out) in tabular or pictorial form.
    c. Outline a recommended maintenance schedule with reference to the applicable pages in the manufacturer's maintenance manuals. Where inadequate maintenance information is provided by the manufacturer, provide the information necessary for proper maintenance.
    d. Outline a recommended plan for a normal maintenance period of at least one year, including a list of necessary and recommended replacement parts.
    e. Assume the reader of this manual to be technically competent, but unfamiliar with this particular facility.
    f. Submit equipment manufacturer’s operation and maintenance manuals for each piece of equipment.
4. Programming/Software:
    a. Submit the project’s control system programming and audio processor configuration files – refer to “Software License” below.

1.6 QUALITY ASSURANCE

A. Audiovisual Contractor Requirements: Demonstrate that your firm meets or exceeds the following requirements:
    1. Five years’ experience, minimum, with the design, engineering, assembly, installation, start-up and maintenance of audiovisual systems of similar or greater complexity to those identified in this specification
    2. Provide the necessary professional design, engineering, fabrication, installation, and project management personnel to execute the work of this section, and to guarantee a complete, functional system in compliance with the design intent

3. Successfully completed in the past 24 months a minimum of three projects of similar scope
4. Current state contracting license, as required to perform the work under this section
5. Bondable to 100% of contract value
6. Be an authorized supplier and installer for equipment listed in this section
7. Maintain permanent fabrication, service and support facilities within 100 miles of the Project site.

B. Audiovisual Contractor Certifications: Demonstrate that your firm has the following certifications:
1. An InfoComm CTS-I (Certified Technology Specialist-Installation) certified employee to actively manage this project – the Engineer will verify CTS credentials at the InfoComm website.
2. An Extron Control Specialist-certified employee to be actively involved in the design, implementation and commissioning of systems in this project – the Engineer will verify Control Specialist with Extron.
3. A QSC Q-Sys Level 2-certified employee to be actively involved in the design, implementation and commissioning of systems in this project – the Engineer will verify Q-Sys credentials with QSC.

C. Manufacturer/equipment Supplier Requirements: Demonstrate that your firm meets or exceeds the following:
1. Operate their business for not less than five years

D. Subcontractor Quality:
1. Specifically identify in the bid submission, for Owner, Architect, or Engineer's approval, all subcontractors that will be used.
2. Regardless of any subcontract arrangement, your firm will have sole responsibility for the successful implementation of the work in this section.

1.7 PROJECT MANAGEMENT AND COORDINATION

A. Comply with the Project Management requirements of section 270000.

B. Assign a project manager to this project for the entire duration. They shall oversee the design, submittals, implementation, testing, and close out – the entire process from start to finish. The project manager shall also coordinate this work of this section with other trades.

C. Report to the Engineer any conditions that would prevent the correct installation of the system as designed.

D. This project requires an programming contractor. Definitions of the equipment programming responsibilities of each are defined below.
1. Programming Contractor
   a. Touch panel layout and user experience, coordinated with the Owner's representative and TEECOM.
   b. Standard control and user interface development specific to the functionality of the audiovisual control systems and communication with controlled devices in the systems.
   c. Installation and validation of the systems and UI code on-site.
   d. Optimize and integrate Building Management System License with corresponding systems – room scheduling displays, HVAC, occupancy sensors, etc.
2. Audiovisual Systems Contractor
   a. Audio processor programming including signal routing, system optimization, and integration of control triggers.

b. Wireless microphone frequency coordination.
c. Video matrix configuration including routing, scaling, and EDID optimization.

3. Coordination Requirements
   a. Audiovisual contractor: provide a device table to the independent programming contractor including an IP address table, source input connections in matrices and output connections in matrices and corresponding end points.
   b. Audiovisual contractor and independent programming contractor: conduct coordination meetings every two weeks and supply meeting notes to TEECOM and the Owner.
   c. Audiovisual contractor and independent programming contractor: conduct collaborative on-site troubleshooting and system tuning sessions for the Project.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage, and Handling requirements of section 270000.

1.9 WARRANTY

A. Warrant the System for a minimum of one year from the date of system acceptance by the Owner. Honor component warranties per manufacturers' terms if greater than one year.
   1. Include service as described in 3.13 "Maintenance and Extended Service" in the warranty.

B. Activate manufacturers' equipment warranties in the Owner's name. The warranty period shall commence on the date of System Acceptance by the Owner.
   1. In the case of contractor-modified equipment (where the manufacturer's warranty could be voided), warrant such equipment equivalent to that of the original manufacturer.

C. Warrant the Software and version updates – see "Software" below.

1.10 SOFTWARE LICENSE

A. Nondisclosure
   1. During or after the termination of this Agreement, the Owner agrees not to disclose any proprietary information provided by the AV Contractor, to maintain such information as confidential and not use such information provided in Project documents for any purpose other than maintenance and support of in-house systems. This does not apply to any of the information that becomes generally known to the public due to publication or other legal means and through no fault of the Owner.

B. Obligations Governing the Software
   1. The AV Contractor shall own the copyright of any custom created software/parameter files ("Software") and hereby grants the Owner a royalty-free, non-exclusive license to use the Software for use with the audiovisual and other connected systems in this project. This license cannot be transferred.
   2. The Owner shall not rent, loan or re-license rights to use the Software to any third party.
   3. Any Third-party software provided or made available to the Owner by the AV Contractor, but not created by the AV Contractor, is sublicensed to the Owner through the AV Contractor. The AV Contractor agrees that such sublicense is granted with consent of the third-party at no cost to the Owner, and the Owner shall be entitled to use such software under the same terms as the AV Contractor.

4. The AV Contractor and third-party suppliers are not restricted from licensing the Software or any portion thereof to other customers.
5. At acceptance testing, provide the source code for custom created software, applications required to use the source code, descriptions of the required equipment, and instructions detailing the modification and installation of the Software to the Owner.

C. For project and custom Software, the following apply.
1. Provide the source code to the Owner either directly via file transfer or make it available through other means, such as cloud storage, an FTP site, etc. Maintain older versions within a folder structure and make them available to the Owner at the Owner's request. At the end of the warranty period, release the current and older versions of the source code to the Owner. If the AV contractor ceases to exist during the warranty period, release the source code to the Owner upon termination of the business.
2. Provide the Software in a form suitable for immediate access by the System.
3. The AV contractor grants the Owner the right to modify and to enhance the Software as furnished and licensed under the terms of this Agreement at its own risk and expense, and further agrees such modifications and enhancements developed by the Owner to be the property of the Owner. Any changes to the custom created software parameter files do not affect copyright ownership.
4. During the warranty period, if the Owner discovers that the Software is no longer functioning in the same manner as had been approved at the beginning of the warranty period, they shall document the fault in sufficient detail to allow errors to be reproduced, and they will notify the AV contractor. Within two business days of this notification, update the software, provide or post updated Software files as detailed above, demonstrate that the error has been resolved, and maintain updated Software files as detailed above.
5. Defend any suit brought against the Owner and pay any damages due to the resulting judgment from any suit brought against the Owner as it pertains to a violation of copyrights or patents of the Software or licenses. The Owner shall notify the AV contractor in writing promptly and give authority, information and assistance at the AV Contractor's expense.
6. The AV contractor at its own expense and option shall, if able, procure for the Owner the right to continue to use the Software as licensed or to replace it with a non-infringing release. This shall not include any agreement by the AV Contractor to accept liability for patent or copyright infringement for beyond the Software as licensed and furnished for the Project. This also excludes any agreement by the AV contractor to accept liability for patent or copyright infringements for methods and processes to be carried out by using said Software except those inherent in the furnished System.
7. All contracts with Third-party software suppliers will transfer from the AV Contractor to the Owner at Project acceptance by the Owner.
8. The Owner shall apprise the AV Contractor of activities it takes with Third-party software providers during the warranty period. Included activities would include discontinuing the use of any Software component, installing updated or alternate versions of the Software, revising the configuration of affected systems.
9. The Owner can contact the AV Contractor for questions at no additional cost during the warranty period, providing:
    a. The queries are related to the audiovisual systems defined in this document.
    b. The query is asked by the Owner's staff or an authorized representative.
    c. The inquirer has attended the AV Contractor's or the manufacturer's training in the use of the systems defined in this document.
    d. The question is not intended as design consultation.
10. The Owner can only make copies as backup files of the Software and they are required to include the AV Contractor's copyright notice. The Owner shall make a reasonable effort to secure this Software to prevent theft or unlicensed usage.

D. Software License Terms
   1. The Software license is granted by the AV Contractor for the devices provided for the Systems. If any devices in the system fails, the license can be transferred to a replacement device on a temporary or permanent basis if the original device is to be phased out. The transference may only occur with written notification to the AV Contractor.
   2. Additional licenses or changes to the Software are subject to a supplemental agreement between the AV Contractor and the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Comply with the Products requirements in section 270000.

B. Provide products, equipment and software that are the latest version of the specified model or type available at the time of procurement, providing the updated devices provide the same or better capabilities and performance required by the system design.

C. Only where denoted “or equal”, equal products will be considered. The manufacturers, product numbers, and types listed at those instances establish minimum performance.

D. Substitutions: The Engineer may consider substitutions for certain equipment if the Contractor demonstrates that the substitution meets or exceeds the functional requirements described in the System Description and Performance Standards. Follow the requirements of section 012500 “Substitutions” for substitution requests.

2.2 EQUIPMENT SCHEDULE

A. Quantities: Quantities are either listed herein with a number, as “A/S” (as shown), or as “A/R” (as required). If listed as A/R or the quantity is marked with an asterisk, determine quantities as required for a fully operational system. Confirm the quantity listed here against the drawings. If the quantity is different than shown on the drawings, the drawings govern quantity and the specifications govern quality.

B. Centralized Software-Based Management
   1. Provide a web-based AV resource management and remote control application to manage, monitor, and control AV equipment and other devices using a standard TCP/IP network.
      a. Extron Global Viewer/Global Configurator
      b. Or Equal

C. **Group Study Rooms**

Description	**Make**	**Model**	**Qty.**	**Notes**
Category: Audio				
Category: Video				

Description	Make	Model	Qty.	Notes
Category: Control				
Category: Accessories				

D. **Meeting Rooms**

Description	Make	Model	Qty.	Notes
Category: Audio				
Category: Video				
Video Display			1	
Wall Mount			1	
Category: Control				
Category: Accessories				

E. Office of IT Director

Description	Make	Model	Qty.	Notes
Category: Audio				
Category: Video				
Video Display			1	
Wall Mount			1	
Category: Control				
Category: Accessories				

F. Classroom Type 1

Description	Make	Model	Qty.	Notes
Category: Audio				
Ceiling mounted loudspeakers	Extron Or Equal		A/R	
Assistive Listening System	Listen Technologies	Assistive Listening System	A/R	
Category: Video				
Video Projector	Panasonic or Equal		2	
Projection lens	Panasonic or Equal		2	

Description	Make	Model	Qty.	Notes
Presentation System	Extron Or Equal		1	
Video Extender Set, HDMI, shielded CAT6 interconnect	Extron Or Equal		A/R	
Collaboration System, Wireless	Extron Or Equal		1	
Document Camera, HDMI, interactive	Elmo Or Equal		1	
Category: Control				
Control Keypad	Extron Or Equal		1	
Category: Accessories				
Wall Plate, HDMI	Extron Or Equal		1	
Wall Plate, HDMI/VGA	Extron Or Equal		1	
Projection Screen, Manual, 16:10	Da-Lite Or Equal		2	
Equipment Cabinet, Plenum-rated	Extron Or Equal		1	

G. Classroom Type 2

Description	Make	Model	Qty.	Notes
Category: Audio				
Ceiling mounted loudspeakers	Extron Or Equal		A/R	
Assistive Listening System	Listen Technologies	Assistive Listening System	A/R	
Category: Video				
Video Projector	Panasonic or Equal		2	
Projection lens	Panasonic or Equal		2	
Presentation System	Extron Or Equal		1	
HDMI Distribution Amplifier	Extron Or Equal		1	
Video Extender Set, HDMI, shielded CAT6 interconnect	Extron Or Equal		A/R	
Collaboration System, Wireless	Extron Or Equal		1	
Document Camera, HDMI, interactive	Elmo Or Equal		1	
Category: Control				
Control Keypad	Extron Or Equal		1	

Description	Make	Model	Qty.	Notes
Category: Accessories				
Wall Plate, HDMI	Extron Or Equal		1	
Wall Plate, HDMI/VGA	Extron Or Equal		1	
Projection Screen, Manual, 16:10	Da-Lite Or Equal Or Equal		2	
Equipment Cabinet, Plenum-rated	Extron Or Equal		1	

H. **Classroom Type 3**

Description	Make	Model	Qty.	Notes
Category: Audio				
Ceiling mounted loudspeakers	Extron Or Equal		A/R	
Assistive Listening System	Listen Technologies	Assistive Listening System	A/R	
Category: Video				
Video Projector	Panasonic or Equal		1	
Projection lens	Panasonic or Equal		1	
Presentation System	Extron Or Equal		1	
Video Extender Set, HDMI, shielded CAT6 interconnect	Extron Or Equal		A/R	
Collaboration System, Wireless	Extron Or Equal		1	
Document Camera, HDMI, interactive	Elmo Or Equal		1	
Category: Control				
Control Keypad	Extron Or Equal		1	
Category: Accessories				
Wall Plate, HDMI	Extron Or Equal		1	
Wall Plate, HDMI/VGA	Extron Or Equal		1	
Projection Screen, Manual, 16:10	Da-Lite Or Equal Or Equal		1	
Equipment Cabinet, Plenum-rated	Extron Or Equal		1	

I. **Classroom Type 4**

Description	Make	Model	Qty.	Notes
Category: Audio				
Ceiling mounted loudspeakers	Extron Or Equal		A/R	
Assistive Listening System	Listen Technologies	Assistive Listening System	A/R	
Category: Video				
Video Projector	Panasonic or Equal		1	
Projection lens	Panasonic or Equal		1	
Presentation System	Extron Or Equal		1	
Video Extender Set, HDMI, shielded CAT6 interconnect	Extron Or Equal		A/R	
Collaboration System, Wireless	Extron Or Equal		1	
Document Camera, HDMI, interactive	Elmo Or Equal		1	
Category: Control				
Control Keypad	Extron Or Equal		1	
Category: Accessories				
Wall Plate, HDMI	Extron Or Equal		1	
Wall Plate, HDMI/VGA	Extron Or Equal		1	
Projection Screen, Manual, 16:10	Da-Lite Or Equal		1	
Equipment Cabinet, Plenum-rated	Extron Or Equal		1	

J. **Writing Center Lab**

Description	Make	Model	Qty.	Notes
Category: Audio				
Category: Video				
Category: Control				
Category: Accessories				

K. **Library Open Reading Area**

Description	Make	Model	Qty.	Notes
Category: Audio				
Category: Video				
Category: Control				
Category: Accessories				

L. Digital Signage

Description	Make	Model	Qty.	Notes
Category: Video				
Video Display			A/R	
Display mount			A/R	
Signage player			A/R	
Category: Accessories				

2.3 CABLES AND WIRES

A. Provide cables and wires that are continuous - without splices.

B. For CATEGORY-type UTP cabling (cables, termination apparatus and installation requirements), refer to section 271513.

C. Cable Selection:
1. Refer to functional diagrams for signal type between equipment.
2. Select a cable with the appropriate rating and configuration required by the applicable building code, electrical code, AHJ, and applicable codes and regulations governing the installation.
3. For cables that will be installed in conduit within on-grade concrete, select a cable rated for underground construction.
4. For cables that will be installed outdoors in underground conduit, aerial, and/or corrosive environments, select a cable rated for outdoor construction.
5. For signal extenders, use extender the manufacturer's recommended cable type and within the maximum cable run length to be used.

D. Unless otherwise called for in these specifications and drawings, the following cables are approved for the associated application or signal type. Ensure the chosen cable is appropriate for the signal type, available pathway capacity, and run length.

Application	**Non-Plenum Product**, or equal	**Plenum Product**, or equal
Ethernet	Refer to section 271513	Refer to section 271513

Application	**Non-Plenum Product**, or equal	**Plenum Product**, or equal
HDBaseT	Belden 2183R West Penn 4246F Extron XTP DTP 24 Superior Essex 6H-246-xA Windy City Wire CAT6S	Belden 2183P West Penn 254246F Extron XTP DTP 24P Superior Essex 6H-246-xB Windy City Wire CAT6SP
Control cable (AMX AXLink, Crestron Cresnet)	Belden 1502R West Penn 77350, C4215 Liberty LLINX-U Windy City Wire CRESCOM	Belden 1502P West Penn D25350 Liberty LLINX-U-P Windy City Wire CRESCOMP
Microphone and line-level audio cable	Belden 9451 West Penn 454 Liberty 20-2C-SH-GRY Windy City Wire 22-1PREZ-BLK	Belden 9451P West Penn 25291B Liberty 20-2C-PSH-GRY Windy City Wire 22-1PREZP-BLK
Program loudspeaker cable	Belden 5000UE West Penn 227 Liberty 12-2C-GRY Windy City Wire 12-02-GRY	Belden 6000UE West Penn 25227B Liberty 12-2C-P-BLK Windy City Wire 12-02P-BLK
Distributed loudspeaker speaker cable	Belden 5300UE West Penn 224 Liberty 18-2C-GRY Windy City Wire 18-02-BLK	Belden 6300UE West Penn 25224B Liberty 18-2C-P-BLK Windy City Wire 18-02P-BLK
ALS emitter	See Antenna cable (wireless microphone) – 50-ohm, below	
Antenna cable (wireless microphone) – 50-Ohm	West Penn 813 Liberty RG8-CMR-BLK RG8-BLK Or equal by Belden	West Penn 2598G8 Liberty RG8-CMP-BLK RG8P-BLK Or equal by Belden
Antenna cable (wireless microphone) – 75-Ohm	See CATV trunk and drop cables, below	
Analog video coaxial cable, RG59-type	Extron 815 Liberty RG59-CCTV-CM-BLK Windy City Wire RG59-BLK	Extron 25815 Liberty RG59-CCTV-PL-BLK Windy City Wire RG59P-BLK
Serial digital coaxial cable	West Penn 819 Liberty 20-CMR-VIDEO-BLK Windy City Wire RG59HD-BLK	West Penn 25825 Liberty 20-CMP-VID-COAX-BLK Windy City Wire RG59HDP-BLK

2.4 CUSTOM REMOTE-CONTROL PANELS AND INTERFACE PLATES

A. For custom remote-control panels and interface plates, use 1/8 inch (3mm) thick #6061 T6 aluminum, with a brushed, anodized, black finish (or as approved by the Architect via submittals).

2.5 EQUIPMENT PLATES

A. For equipment plates, utilize 1/32" to 1/16" thick by 1/4" high aluminum with a brushed anodized black finish.

B. Provide engraved lettering 1/8" to 3/16" high.

2.6 LABELS

A. General: Labels shall meet UL 969 product requirements.

B. Equipment Labels:
   1. Equipment labels shall be machine printable, shall be polyester (or similar) adhesive-back type, and shall be permanent.
   2. Face stock (print area) shall be white.
   3. Size: as needed.
   4. Manufacturer, or equal:
      a. Brady
      b. Brother
      c. DYMO XTL or Rhino
      d. Panduit
         1) #C150X075YJJ; component label, laser/inkjet print, white face stock 1.5"W x 0.75"H
      e. Thomas and Betts

C. Cable and Wire Labels:
   1. Cable and wire labels shall be machine printable, shall be permanent, and shall be either of the following types:
      a. Tape – machine-printable, wrap-around, self-laminating, permanent adhesive-backed tape
      b. Machine-printable, shrink-wrapped labels
   2. Face stock (print area) shall be white.
   3. Size: as needed per wire/cable size (approximately 1" wide).
   4. Manufacturer, or equal:
      a. Brady
      b. Brother
      c. DYMO XTL or Rhino
      d. Panduit
         1) #S100X075YAJ; self-laminating cable label, white face stock 1"W, for cable diameters 0.08"-0.16"C150X075YJJ
         2) #S100X125YAJ; self-laminating cable label, white face stock 1"W, for cable diameters 0.12"-0.28"
         3) #S100X150YAJ; self-laminating cable label, white face stock 1"W, for cable diameters 0.16"-0.32"
         4) #S100X225YAJ; self-laminating cable label, white face stock 1"W, for cable diameters 0.24"-0.48"

D. Loudspeaker Labels:
   1. Loudspeaker labels shall be polyester (or similar) adhesive-back type, shall be permanent, and shall be machine printable with a printer.
   2. Face stock (print area) shall be white.
   3. Size: as needed.
   4. Manufacturer, or equal:
      a. Brady
      b. Brother
      c. DYMO XTL or Rhino
      d. Panduit
         1) # C075X050YJJ; component label, laser/inkjet print, white face stock 0.75"W x 0.5"H

2.7 RACK BONDING

A. Refer to section 270526 for approved bonding products.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of section 270000.

B. Perform work in accordance with the standards and best practices defined by the AVIXA coursework for Installation 1: System Fabrication and Installation 2: Setup and Verification.

C. Install products per manufacturers' instructions.

D. Install panels, equipment, boxes, etc., plumb and square.

E. Seismic Safety:
   1. Mount, anchor and/or brace permanently-installed equipment to the building structure using anchors, fastenings, supports, and methods approved by structural engineer with a safety load factor of at least 1.5. Provide installations that meet the most stringent of applicable codes and regulations to minimize potential damage to personnel and equipment from foreseeable seismic events.
   2. Brace hanging audiovisual and associated equipment both to minimize sway and to prevent detachment from the overhead structure in accordance with applicable codes.
   3. Firmly secure equipment in place unless requirements of portability dictate otherwise.

3.2 EXAMINATION

A. Prior to starting the work of this section, examine areas to receive system components and pathways to receive cabling to verify conditions are ready for work of this section and to verify conformance with manufacturer and specification tolerances.
   1. Verify that pathways, including conduit, junction boxes, cable trays, ceiling enclosures, etc., are in place prior to placing cables into pathways and as required by applicable codes.
   2. Verify that rough-in (including conduit, device boxes, floor boxes, and the like) is ready to receive wiring, cabling, devices, equipment, and the like prior to installing into the rough-in.
   3. Verify that electrical power service is ready and stable prior to connecting equipment.
   4. Verify that support infrastructure, including equipment racks, are in place prior to installation.
   5. Check ceiling types, ceiling heights, and clearances above ceilings to ensure conditions are appropriate per manufacturer's installation requirements.

B. Verify that the network is operational and ready to receive connection from and configuration for the System. "Ready" includes settings on the network required for the System to function properly. Coordinate with the network contractor as needed to ensure the network settings have been adjusted to support full functionality of the System.

C. Proceed with installation work only after unsatisfactory conditions are corrected.

3.3 INSTALLATION

A. Floor-Standing Equipment Racks
   1. Completely assemble equipment racks. Include parts and accessories, such as electrical power distribution devices, cable dressing accessories, and blank and vent panels, required for a complete result.
   2. Anchoring/bracing: Anchor racks to the floor at four points per approved structural details using anchors and methods approved by a structural engineer. Seismically brace racks (e.g., using brackets, threaded rod with strut, etc.) as required, attached to the wall or structure above using appropriate anchors or fasteners.
   3. Tolerances: Verify dimensions to establish proper clearances. Install racks to attain clearance of at least 36” to the nearest piece of equipment from each enclosure’s front and back doors.
   4. Power strips: Install power strips on the back interior of the rack space on the left side as viewed from the back.
   5. Lighting: Install lights on the back interior of the rack space centered within the rack, magnetically attached or fastened to the frame, and situated to illuminate the back of the rack-mounted equipment and wiring.
   6. Bonding/Grounding: Connect the equipment rack frame to an approved ground point using a 6 AWG bonding conductor and approved connectors. (Here, an approved ground point may be a busbar within the room or the ground of the branch circuit serving the rack.) In the rack, connect the bonding conductor to the rack’s connection point such as a threaded grounding post or a bonding pigtail, or attached to the frame (per manufacturer’s instructions for bonding connections).

B. Pedestal and Credenza-Type Equipment Racks
   1. Completely assemble equipment racks. Include parts and accessories, such as electrical power distribution devices, cable dressing accessories, and blank and vent panels, required for a complete result.
   2. Anchoring/bracing: Anchor racks to the floor at four points per approved structural details using anchors and methods approved by a structural engineer.
   3. Bonding/Grounding: Connect the equipment rack frame to an approved ground point using a bonding conductor (12 AWG up to 6 AWG) and approved connectors. (Here, an approved ground point may be the ground of the branch circuit serving the rack or an approved conductor to the ground bus of the electrical panel serving the rack.)
   4. Cooling provisions: Coordinate cooling provisions (means to prevent equipment from overheating) within rack/credenza/etc., such as inlet and exhaust openings, exhaust fans, etc. All of the installed equipment must be capable of working continuously with the enclosure closed normally while staying within manufacturers’ operating temperature specifications. Acceptance testing will include temperature verification.

C. Slide-out Equipment Racks
   1. Coordinate installation with millwork, casework, and other trades. Ensure that the construction that will receive the rack is properly prepared (framed, finished, braced, backed, etc.).
   2. Completely assemble slide-out equipment racks. Include parts and accessories, such as electrical power distribution devices, cable dressing accessories, and blank and vent panels, required for a complete result.
   3. Attach racks to receiving surfaces (such as millwork) using fasteners approved for the application.
   4. Where power strips are required, install them onto the back-side of the slide-out rack’s base.

5. Bonding/Grounding
    a. Connect the equipment rack frame to an approved ground point using approved connectors and 12 AWG (or larger up to 6 AWG) bonding conductor. (Here, an approved ground point may be the ground of the branch circuit serving the rack.)
6. Cooling Provisions
    a. Coordinate cooling provisions (means to prevent equipment from overheating) within millwork/casework/cabinets, such as inlet holes/openings, exhaust fan openings, power service, etc. At a minimum, ensure airflow by installing active cooling devices or systems such as fans.
    b. Adapt cooling provisions to suit the configuration of each instance.

D. Displays and Mounts
1. Wall-Mounted Displays: Install mounts using fasteners approved for the mounting substrate. For framed walls, firmly engage fasteners into backing or, if no backing is present, into framing studs.
2. Ceiling-Mounted Displays: Install mounts to structure using fasteners and mounting accessories approved for the mount and mounting substrate. Install seismic restraints as appropriate for the installation location. Conceal cabling within mounting columns where feasible.
3. Securely install displays onto mounts. Complete final connections (power, signal, control, etc.).
4. Install accessories onto mounts or displays using approved attachment methods that guarantee the longevity of the installation. Accessories may be attached mechanically, if allowed by the display/mount manufacturer, or by using 3M TB3571/3572 hook and loop fastener tape or an approved equal.
5. Dress cables; ensure they are maximally concealed yet serviceable.
6. Adjust each display and mount to attain a true, square, and level installed result.

E. Video Walls (arrays of individual displays assembled to create a larger composite image)
1. Position all displays physically to align in a common plane.
2. Position all displays to have equal gaps between them. Provide gaps per the display manufacturers' specifications.
3. Verify consistent gapping by displaying full-screen images with horizontal, vertical, and diagonal lines. The evidence of proper alignment will be zero line offsets between adjacent displays.
4. Adjust displays or video wall processors for proper bezel compensation.
5. Verify correct bezel compensation by displaying full-screen images with diagonal lines. The evidence of proper adjustment will be an absence of line offsets between adjacent displays.

F. Projection Systems
1. Projector Supports
    a. Anchor poles to structure using means approved by a structural engineer.
    b. Install lateral and/or transverse bracing to poles for seismic bracing as required.
    c. Securely install mounts onto poles using compatible adapting components.
2. Projectors
    a. Securely install projectors to mounts.
    b. Fully assemble and install projectors, lenses, and mirrors such that the final condition will be no observable movement in the image induced by motor vibration or other mechanical operations.
    c. Install accessories onto mounts or projectors using approved attachment methods that guarantee the longevity of the installation. Accessories may be attached mechanically, if allowed by the projector/mount manufacturer, or by using 3M TB3571/3572 hook and loop fastener tape or an approved equal.

3. Align projection systems so projected images fill the viewing areas of the associated projection screens and exhibit no geometric distortion.
4. Only use physical and/or optical adjustments to correct geometric distortion.
5. Only use electronic or digital correction when called for in this document package.
6. Confirm that the total averaged light output from all projectors, in lumens, is at least 85% of that specified by the projector manufacturer.
7. Confirm that the light falloff from the center of the projected image to four corners, as measured at the projected image plane, does not exceed 50%.

G. Ceiling Microphones
1. Review field conditions, and coordinate with the Architect or Engineer to resolve conflicts with other trades' devices conflicting with microphone locations.
2. Route analog microphone cabling away from other cabling types. Where this cabling must cross other cabling types, install it at a 90° angle.
3. Install microphone preamplifiers, conversion devices, and other back boxes using safety wires attached to the building structure.
4. Prior to acceptance testing, confirm microphones do not produce audible buzz and/or noise.

H. Table Microphones
1. Review table drawings, and coordinate with the Architect and Engineer to resolve conflicts with other tabletop or through-table devices conflicting with microphone locations.
2. Coordinate microphone locations and installation activities with the Architect and Engineer prior to installing through-tabletop microphones and microphone receptacles.
3. Route analog microphone cabling separated from other cabling types to prevent signal interference. Where this cabling must cross other cabling types, cross it at a 90° angle.
4. Install microphone preamplifiers and other microphone-related conversion devices neatly, square to the table, and as hidden from view as possible. Coordinate the locations of these devices with the Architect and Engineer.
5. Label and dress all cables neatly and with approved cable management products.
6. Prior to acceptance testing, confirm microphones produce no audible buzz and/or noise.

I. Wireless Microphone Systems
1. Mount antennas external to equipment racks.
2. For wireless microphone systems using multiple antennas, space them per manufacturers' recommendations.
3. For VHF and UHF wireless systems, use RF coordination software (such as Shure Wireless Workbench) to scan and coordinate frequencies of all wireless microphone systems to be installed into the project.
    a. Avoid local public safety channels when assigning frequencies.
    b. Verify frequency assignments do not interfere with each other and are free from dropouts

J. Antennas
1. Use antennas designed specifically for the frequency bands they will carry.
2. For antennas extended from the attached equipment, use cabling appropriate for the frequency and distance.
3. Use extender devices (preamplifiers) and distribution amplifiers per cabling lengths and manufacturers' recommendations.
4. Install cabling per manufacturers' bend radius guidelines.
5. Locate and orient antennas to ensure coverage throughout the room(s). Verify this by walk-testing systems.

K. Loudspeaker Tap Settings
   1. Where loudspeaker tap wattages are specified in the design documents, set transformers per these. Otherwise, set taps per best practices.
   2. Set taps such that the total wattage of a series of loudspeakers will not exceed 75 percent of the associated amplifier's rated wattage.
   3. Record tap settings per loudspeaker for inclusion on the as-built drawings.

L. Loudspeakers, Wall, Surface-Mounted
   1. Install loudspeakers per manufacturers' recommendations and the design documents.
   2. Install loudspeakers plumb and square.
   3. Use security mounting hardware where loudspeakers will be mounted below 10' AFF.
   4. Provide security cables per codes and best practices.
   5. Where manufacturer labels are visible on loudspeaker grills and are rotatable, align these to read correctly.
   6. Where loudspeakers will be exposed to humidity or water spray, ensure water will not be able to penetrate cable connections.

M. Loudspeakers, Acoustical Tile, Ceiling-Mounted
   1. Coordinate ceiling tile work (such as cutting holes) with the ceiling contractor.
   2. Unless directed otherwise, center ceiling loudspeakers to ceiling tiles and evenly space loudspeakers.
   3. Cut ceiling tiles to fit loudspeaker such that no gaps are visible after the loudspeaker cover/grille is installed.
   4. Install ceiling loudspeakers with safety wires attached to the building structure per applicable codes and best practices.
   5. Use tile rails and other support components to ensure loudspeakers do not sag.
   6. Where manufacturer labels are visible on loudspeaker grills and are rotatable, align these consistently.
   7. Replace ceiling tiles damaged during loudspeaker installation work.

N. Loudspeakers, Gypsum (hard lid) Ceiling-Mounted
   1. Coordinate ceiling work (such as cutting holes) with the framing contractor.
   2. Unless directed otherwise, align and evenly space loudspeakers.
   3. Cut wallboard to fit loudspeaker such that no gaps are visible after the loudspeaker cover/grille is installed.
   4. Install ceiling loudspeakers with safety wires attached to the building structure per applicable codes and best practices.
   5. Where manufacturer labels are visible on loudspeaker grills and are rotatable, align these consistently.

O. Room Scheduling Displays
   1. Coordinate with the general contractor and specialty contractors to conceal cabling in glazing system frame members.
   2. Room Scheduling displays will be provided in the future. Provide cabling to support future system.
   3. Provide service loops to allow displays to be removed prior to disconnection.

P. Digital Signage
   1. Make digital signage players accessible and controllable via the network and via web access.
   2. Coordinate with the Owner to determine configuration and/or initialization files are required by players/receivers to be managed by the Owner's local or cloud-hosted management platform.
   3. Coordinate with the Owner's Representative to ensure a successful implementation of this requirement.

Q. Cabling and Wiring at Racks
1. Do not use electrical tape for bonding, splicing, joining, or any other purpose.
2. As a general practice, run power cables, control cables, and other cables with higher voltage levels on the left side of an equipment rack as viewed from the back; run other cables with lower voltage levels on the opposite side. Where wiring issues or wire routing facilities preclude this configuration, it is acceptable to deviate from the directions above, if separation is maintained between signal and electrical power cables.
3. To reduce signal contamination, group cables per the signals being carried. Maintain appropriate distances between cable groups, especially between high-current (power; loudspeaker) and low-current (microphone) groups. Form separate groups for the following cables/signal types:
    a. Power
    b. Control
    c. Analog video
    d. Digital audio and video
    e. Analog microphone audio
    f. Analog line audio
    g. Loudspeaker audio
    h. Radio frequency
4. Within racks, install wires and cables with service loops. Provide sufficient cable to allow each piece of equipment to be removed from the front of the rack for servicing.
5. At boxes or points of termination, install wires and cables with service loops. Provide sufficient cable to allow each piece of equipment to be removed and laid flat on a surface for servicing.
6. At slide-out equipment racks, dress cables to allow racks to be extended to the maximum length of the rack slides. For slide-out rotating racks, provide sufficient cable to allow full extension and rotation.
7. For cables that interface with racks, cabinets, consoles, or equipment modules, use screw-type terminal blocks, terminal strips, or connectors. Telephone-style punch-down blocks (e.g., 110 blocks) are not acceptable.
8. Do not bend any cable or wire tighter than the manufacturer's minimum bend radius.
9. Install wires and cables such that the cable exerts no strain on its termination.
10. Label wires and cables, regardless of length, using a cable label with a unique number or letter per the instructions below under "Labeling".
11. Cable Shield Bonding: For cables with shields, connect them using approved connectors per an approved grounding topology.
12. Encase umbilicals (groups of bundled cables) connecting moveable racks and cabinets to walls and other fixed locations in braided sleeving. Where racks and cabinets are installed in view of non-technical people, coordinate sleeving colors with the Architect.

R. Cabling and Wiring – Overhead Distribution
1. Use cabling appropriate to loudspeaker impedance, cabling distance, and installation conditions (such as plenum versus non-plenum).
2. The use of electrical tape for bonding, splicing, joining, or any other purpose is prohibited.
3. Provide cable runs between termination points that are continuous, with sheath continuity. Splices are not permitted anywhere.
4. Place cables within designated pathways, such as cable tray, cable hangers, etc. Do not fasten cables to other building infrastructure (such as ducts, pipes, etc.), other systems (such as ceiling support wires, wall studs, etc.), or to the outside of conduits, cable trays, or other non-approved pathway systems.
5. Protect cables from physical interference and damage during installation and termination. Install cables with no kinks or twists.
6. Install HDBaseT cables within manufacturers' length recommendations.
7. Comply with manufacturers' limits for pulling tension.
8. Do not use cable-pulling compounds for indoor installations.

9. Install cables within manufacturers' bend radius limits. If no minimum bend radius is given, then maintain a minimum bend radius of six times the cable diameter during and after installation.
10. Route cables under building infrastructure (such as ducts, pipes, conduits, etc.); do not route cables over building infrastructure. Install cables to provide accessibility for future service.
11. Place cables 6", minimum, away from power sources to reduce interference from EMI.
12. Connectors: Use the following connectors:

Category	Subcategory	Type	Acceptable Manufacturers				Comments
Audio	Low-level	RCA / S/PDIF	Switchcraft	Pomona			
Audio	Low-level	3.5mm TRS	Switchcraft	Neutrik	Amphenol		
Audio	Low-level	1/4" TS/TRS	Switchcraft	Neutrik	Amphenol		
Audio	Low-level	XLR	Switchcraft	Neutrik	ITT Cannon		
Audio	Low-level	Combo XLR/TRS	Neutrik				No substitutions
Audio	Low-level	TA-series (mini XLR)	Switchcraft				No substitutions
Audio	Low-level	Microdot	Lemo				
Audio	Microphone, no mute control	XLR-3	Switchcraft	Neutrik	ITT Cannon		
Audio	Microphone, with mute control	XLR-5	Switchcraft	Neutrik	ITT Cannon		
Audio	Microphone under table or desktop, no mute	R3F	Switchcraft	Neutrik	ITT Cannon		
Audio	Microphone under table or desktop, with mute	R5F	Microphone under table or desktop, no mute				
Audio	Low or high-level	Phoenix	Phoenix Contact				
Audio	High-level	Banana	Pomona	GC Electronics			
Audio	High-level	Speakon	Neutrik	Switchcraft			
Video	50-ohm	BNC	Kings	AMP - TE Connectivity	Trompeter	Amphenol	
Video		Triax	Trompeter				
Video		HDMI bulkhead barrel	Switchcraft	Cliff	Neutrik	Harting	
Video		HDMI cable	Extron	Crestron			
Video		DisplayPort cable	Extron	Crestron			
Video		Mini DisplayPort/	Extron	Crestron	Apple		

Category	Subcategory	Type	Acceptable Manufacturers				Comments
		Thunderbolt cable					
Video	D-sub	HD-15 ("VGA") cable	Extron	Crestron	Cables to Go		
RF	75-ohm	BNC	Kings	AMP - TE Connectivity	Trompeter	Amphenol	
RF		F-type	Belden	Amphenol	Liberty	Digicon	
RF		UHF	Amphenol				
Control	D-sub	DB-9, DB-25	Amphenol	TE Connectivity			
Control	Phoenix		Phoenix Contact				Or as provided with equipment
Control	Modular	4p4c plug	Cinch Connectivity	Molex	TE Connectivity	Hirose	
Control	Modular	8-contact	Ortronics	Panduit	Belden	Molex	
Control	USB cable	A, B, C types	Extron	Crestron	Hosa	Belkin	
Control	Crimp	Fork lug	TE Connectivity	Molex	Phoenix Contact		
Control		XLR	Switchcraft	Neutrik	ITT Cannon		
Control		DIN	CUI	Hirose			
Control	etherCON	RJ45	Neutrik				
Fiber		FC	Molex	TE Connectivity	3M		
Fiber	opticalCON	Click-on duplex	Neutrik				
Fiber		LC	Molex	TE Connectivity	3M		
Fiber		LC Duplex	Molex	TE Connectivity	Conec		
Fiber		SC	Molex	TE Connectivity	3M		
Fiber		SC Duplex	Molex	TE Connectivity	3M		
Fiber		SMA	Industrial Fiberoptics	TE Connectivity	Phoenix Contact		
Fiber		ST	Molex	TE Connectivity	3M		
Fiber		TOSLINK	Tripp Lite				

S. Terminations and Cords at Floor Boxes
   1. Provide strain relief for cables. Use appropriate cable management products (such as hook and loop straps for UTP and STP cabling, and nylon cable ties for other cables) to group similar cable types.
   2. Provide permanent labels on cables within 6" of terminations.

3. Provide permanent labels on receptacles within floor boxes to clearly identify terminations and services.
4. Encase umbilicals connecting moveable racks, cabinets, etc., to floor boxes in braided sleeving. Where racks and cabinets are installed in view of non-technical people, coordinate sleeving colors with the Architect.

T. Blank Panels: Provide blank trim plates in floor, wall and furniture-mounted boxes at unused termination positions. Fill each module opening filled, either with a receptacle, a receptacle plate, or a module of the type the opening is intended to house.

U. Patch Panels
1. Assignments: Wire patch panels so that signal sources appear on the upper row of a row pair; and destinations appear on the lower row of a row pair. Submit variations from this approach per the requirements in Submittals.
2. Designation strips: Utilize alphanumeric identifications and descriptive information on audio and video patch panel designation strips. Number the jack positions in each row sequentially from left to right. Letter the jack rows sequentially from top to bottom. Include the alphanumeric identification of each jack on the functional block drawings. Mount reproductions of these drawings in an appropriate location near the patch bays.

3.4 EDID MANAGEMENT

A. For each system, determine the maximum pixel resolution, frame rate, and color depth supported by all content displays, and designate this as the target resolution for the system. Omit digital signage displays from this process.
1. Scalers: Configure video scalers as follows:
a. Input: Emulate the EDID configuration of the native resolution of the connected display or projector for both analog and digital inputs.
b. Output: Configure to match the native resolution of the display system and at the highest supported scan rate.

B. Determine the system’s maximum audio parameters – output channel count, LFE capabilities, etc.

C. Configure the system’s EDID management to ensure that these audio and video parameters are sent to source devices.

3.5 HDCP MANAGEMENT

A. Include HDCP support in all equipment that incorporates copy protection for the transport of copyrighted media.
1. Installation Requirements
a. Equipment capable of passing HDCP included in this project must support the same HDCP version (i.e. HDCP 1.4 or HDCP 2.2).
2. Exceptions
a. HDCP may be defeated for educational institution projects per ‘fair use’ copyright terms.

3.6 NETWORK SECURITY

A. Leave no network-connected device operating with its factory-default password.

B. Obtain Owner-defined password changes for all network-connected devices. Program these passwords into the devices.

C. Where available, enable two-factor authentication.

3.7 PROGRAMMING AND EQUIPMENT CONFIGURATION

A. General Programming
   1. Install the most current version of manufacturers' firmware on devices.

B. Audio Processor Programming
   1. The following instructions apply to all systems including programmable audio processors and microphones.
   2. Set input devices (wireless microphones, ceiling microphones, video device audio, etc.) to unity gain.
   3. Set output devices to unity gain.
   4. Set amplifiers to maximum gain.
   5. Set gains from microphones on analog and Dante/AES67 input blocks in audio processors to achieve input gains on meters around -15 to -20dBFS.
   6. Set gains on analog and Dante/AES67 output components in audio processors to achieve required output gain from the loudspeakers.
   7. Adjust gating auto-mixer settings so that room participants can be heard clearly with minimal room noise and echo, with no noticeable delay nor cutoff words when talkers begin to speak, and with minimal breathing and other artifacts after talkers stop speaking.
   8. Adjust AEC settings so that no echo can be heard by far-end callers.
   9. Balance program levels between HDMI program audio and USB bridge program audio to within 3 dB.
   10. Coordinate AEC among all processing devices and software in the system so that only one processor in the audio chain, whether physical, such as a hardware DSP, or virtual, such as a software processor in collaboration software, has AEC enabled.
   11. Make equalization and other room tuning adjustments to obtain the flattest and least colored result the system is capable of.
   12. Make additional equalization and other room tuning adjustments to eliminate feedback when the microphones are at maximum system gain. Do not use feedback suppression components.

C. Control System and Touch Panels
   1. Owner's Requirements
      a. Meet with the Owner and document their functional and user interface requirements (backgrounds, color scheme, screens, menus, functions, etc.).
      b. Develop programming and user interfaces based on the user requirements.
      c. Submit touch panel layouts and menu flow documentation to the Owner and Engineer per submittal schedule.
      d. Meet with the Owner and Engineer and present the control system programming and user interfaces. Obtain the Owner's approval on these items.
   2. Programming Guidelines
      a. Create initial screens (splash screens) that use a version of the Owner's logo, generated without visible scaling artifacts.
      b. Only use red for alarm indicators and other screen elements of special significance.
      c. Avoid use of technical terms, rather, use clear, everyday language. For example, instead of "System On", use "Turn System On"; instead of "Power Down", use "Turn Power Off", etc.
      d. Ensure soft buttons are sized consistently and spaced evenly.

e. Ensure spelling, punctuation, and grammar are 100% correct.
f. Provide menus on both touch panels and control system web pages that appear and function consistently throughout the project.
g. Ensure items with similar functions appear consistently in all menus.
h. Provide soft button presses that display visual feedback, and if required by the Owner, audible feedback.

3. Tech Menus: Provide a “tech” (Technician-level) menu for each touch panel. Include in tech menus:
   a. Volume control for button audible feedback
   b. Screen brightness
   c. A means to change the tech screen password; obtain from the Owner’s Representative a default password for all touch panel tech menus or an alternative method for password management, such as the use of Active Directory.
   d. Other technician-specific functions required for each system
4. Make IP control system devices (touch panels, controllers, processors, etc.) accessible and controllable via the network and via web access. For example, users and/or technicians shall be able to operate touch and pushbutton panel functions remotely Coordinate with the Owner’s Representative to ensure a successful implementation of this requirement.
5. In AV-equipped rooms with an operable partition, program the AV system to use signals from the rooms’ partition sensors to automate audiovisual system combine/divide functions.

D. Power Control and Sequencing
1. Whether explicitly listed in this specification or not, provide power control interfaces, e.g., remotely controllable PDUs, for equipment and devices that are not equipped with integrated power control. Provide power control interfaces that are fully compatible with the specified control system. Follow this directive for devices, such as audio power amplifiers, which would not be adversely affected by external power controls. Omit such power controls for devices, such as transmitters and receivers, that should not be externally power controlled.
2. Configure non-controlling items to power off or go into a standby/low power-consumption mode when systems are powered off. At minimum, program the AV system to power off the following types of devices when not in use.
   a. Audio processors
   b. Audio amplifiers
   c. Displays
   d. Projectors
3. Configure devices that detect connection to user devices to stay in standby/low power-consumption mode when audiovisual systems are turned off.
   a. Video switchers and processors
4. When turning systems on, use the following sequence for audio components.
   a. Turn on source devices.
   b. Turn on processing and routing devices.
   c. Turn on amplifiers.
5. When turning systems off, use the following sequence for audio components.
   a. Turn off amplifiers.
   b. Turn off processing and routing devices.
   c. Turn off source devices.

E. BMS Interfacing
   1. Coordinate with the Owner's Representative regarding interfacing between AV power control and the building management system. Comply with the Owner's requirements for reporting power control and/or power usage.

F. Network Connection
   1. Connect all network-connectable equipment and devices to the network. Program them to electronically issue notifications for preventative maintenance (e.g., replace a projector lamp).
   2. Coordinate with the Owner's Representative which devices are to provide notification (e.g., email notification) immediately at the time of a fault and which devices will provide notifications on a daily or weekly report.
   3. Coordinate with the Owner's Representative to obtain the default notification means (e.g., the email address for maintenance messages).
   4. Ensure the Owner's Representative can revise the maintenance email address via a simple method – using a single address for all networked AV devices. Document this procedure in the Operations Manual.

G. Equipment Configuration:
   1. Blu-ray Disk Players: Set color space to RGB.
   2. Computer Interfaces, Signal Extenders and Transmitters with Integral Input Switching: Program devices and related system components so analog audio inputs are active regardless of which video input is selected.

3.8 LABELING

A. Provide labeling identifiers that match closeout documentation (e.g., as-built drawings, O&M Manual, etc.).

B. Clean and degrease surfaces receiving nameplates and labels prior to affixing labels.

C. When creating labels for user-facing equipment and cables, use colored labels where possible. Example uses are floor boxes, table boxes, cameras, displays, and user-facing cables. Use color coding to relate labels to related components, i.e., match the text and color on each user-facing cable, its corresponding button on the button panel, and its corresponding input on the display. Example: HDMI 2 cable has a yellow label printed with "HDMI 2", the button panel at the table box has a yellow "HDMI 2" label and the input on the display has a yellow label printed with "HDMI 2".

D. Interface Plate Designation:
   1. Provide wall-mounted interface plates with clearly engraved alphanumeric identification of input type (e.g., "MIC-1", "LINE IN", "SPEAKER", "VIDEO", etc.) and corresponding patch field designation.

E. Equipment Racks and Cabinets:
   1. Install the label on the top of the rack or cabinet, centered horizontally.
   2. Example: line 1: "AV-01", line 2: "Audiovisual Devices".

F. Equipment
   1. Rack-mounted equipment: Install labels in visible locations on equipment and devices on the front and back of the equipment.
   2. Field equipment: Install labels in visible locations on miscellaneous field equipment and devices.

G. Wireless Transmitters and Receivers: Label wireless transmitters and receivers so users can clearly identify a given transmitter associated with its receiver.
   1. Use an identifier, such as a room number, that associates each transmitter with a given room or system.
   2. Example: RM.230–MIC.3–RCVR.1

H. Wire and Cable:
   1. Comply with the Owner's labeling requirements. If the Owner does not have labeling requirements, conform with AVIXA F501.01.
   2. Provide labels with machine-generated text; hand-written labels will not be accepted.
   3. Use a numbering system with a consistent number of characters for each cable's unique identifier.
   4. Generate a unique identifier for each cable and wire using either the Owner's system or AVIXA F501.01. Include primary level data elements per F501.01; secondary level data elements are optional.
   5. Label Installation:
      a. Install labels on both ends of cables at least 1" (25mm) and no more than 12" (300mm) from the connector strain relief or the heat shrink tube from which individual wires exit the cable jacket.
      b. Labels must be visible; they may not be concealed by strain relief elements or within bundles.
      c. Install labels such that they are visible by a technician from a normal stance.
      d. Install labels according to label manufacturers' guidelines.
   6. Label Legibility:
      a. Text margins shall be a minimum of 1mm in the printable area.
      b. Text shall not be obscured by any part of the label.
      c. Primary text shall be all capitals, no less than 2.5mm tall. Bold is permitted; italics are not.
      d. Secondary text shall be all capitals, no less than 2.1mm tall. Neither bold nor italics are permitted.
   7. Label Consistency:
      a. All primary labels shall have the same width. All secondary labels shall also be the same width, but that width may differ from that of the primary labels.
      b. All label shall be of sufficient height for the outer dimensions to meet the manufacturer's installation.
      c. In environments and applications where additional physical protection is required to preserve label integrity and legibility for the specified design life, apply additional protective materials. In such cases, apply the additional materials to all labels in the system. If a specific design life is not otherwise specified, assume 10 years will be required.
      d. Primary labels shall utilize the same font type, font size, font spacing, and margin spacing except in the case of user-accessible cable labeling. Secondary labels shall utilize the same font type, font size, font spacing, and margin spacing. The properties of the primary labels may differ from the secondary labels, but they shall be consistent within each label type.
      e. Unless defined otherwise within the labeling schema, text shall be the same color. Text color shall present high contrast to the background color of the label. Black text on a white background is preferable, but where any other color scheme is used, a contrast of no less than 3:1 shall be achieved.

3.9 FIELD QUALITY CONTROL

A. Initial Tests and Measurements: Prior to final adjustment and scheduling acceptance testing, perform initial tests and measurements. At minimum, include the following initial tests and measurements:
   1. Adjust, balance, and align equipment for optimum quality and to meet manufacturers' published specifications.
   2. Perform the test procedure provided at the end of this specification and return the completed form no less than one week prior to the initial punch walk.
   3. For rack-mounted equipment with user-accessible controls, install 1/8" diameter vinyl "map dots" as indicators for nominal operating positions of rotary, slider, and other accessible controls. Provide multiple dots, adequately distinguished, for controls having more than one nominal operating position.

B. Twisted-pair Cable Testing: Follow the following procedures to test CATEGORY-type twisted pair cabling.
   1. Equipment, or equal:
      a. Fluke DSX CableAnalyzer
   2. Test Procedure:
      a. Configure the cabling and test set up as a permanent link.
      b. Test each cable under a TIA-568 Permanent Link test script to match the category of the installed cabling.

C. Fiber Optic Cable Testing: Follow the following procedures to test fiber optic cabling.
   1. Equipment, or equal:
      a. MicroCare Fiber Wipes, or equal
      b. SPC FiberXP DI-200 Fiber Optic Inspection Scope, or equal
      c. Fluke DSX-5000, AFL Noyes SMLP4-4 Fiber Optic Loss Test Kit, or equal
   2. Test Procedure:
      a. Using approved materials, clean each connector end face before testing.
      b. Using the inspection scope, inspect each connector end face.
      c. Multi-mode Fibers:
         1) Set up the optical loss test set under either IEC 61280-4-1 Single Reference Cable Method or the TIA 526-14 OFSTP-14 Method B.
         2) Measure the insertion of each fiber. Record the measurements.
         3) Re-terminate or replace cables with fibers that exceed 3 dB at 850 nm and 1 dB at 1,300 nm end-to-end insertion loss.
      d. Single-mode Fibers:
         1) Set up the optical loss test set per TIA-526-7 test method A.1 "One Jumper-Cable Measurement".
         2) Measure the insertion of each fiber. Record the measurements.
         3) Re-terminate or replace cables with fibers that exceed 1.5 dB at 1,310 nm and 1.5 dB at 1,550 nm end-to-end insertion loss.

D. Digital Video Cabling: Follow the following procedure to test each provided digital video cable.
   1. HDMI: Quantum Data 780, or equal
   2. DVI/SDI/HD-SDI: Quantum Data 882D, or equal
   3. DisplayPort: Quantum Data 882E-DP, or equal
   4. Test Procedure:
      a. Test each cable.
      b. Replace all cables that fail.

E. Audio System Testing:
   1. Loudspeaker Line Impedance: Measure the impedance at 63 Hz, 250 Hz, and 1 kHz and the resistance of each loudspeaker line leaving the sound equipment rack with the line

disconnected from its normal driving source. For lines to full range distributed loudspeaker systems, measure impedance at 1 kHz.

2. Hum and Noise Level:
   a. Measure the hum and noise levels of the overall system for each microphone input channel and line level input channel.
   b. Adjust gain controls for optimum signal to noise ratio so that full amplifier output is achieved with 0 dBm at a line level input.
   c. Terminate line level inputs with resistors of 150 and 600 ohms, respectively, for these measurements.
   d. Disconnect the loudspeaker lines and terminate the power amplifier outputs with power resistors for these measurements. Use load resistors within 5% of the nominal load impedance of the amplifier under test. Use resistors with power ratings equal to or greater than the power rating of the amplifiers.
3. System Frequency Response: Measure audio system frequency response for the AV systems described in Part 1. Adjust systems to provide specified performance.
4. Uniformity of Coverage: Using a calibrated testing device, measure octave bands using a pink noise test signal played through the loudspeaker system(s).
5. System Power Output and Signal Level Adjustment:
   a. Measure the electrical distortion of the overall system for each line level input channel.
   b. Adjust gain control as for the tests specified herein.
   c. Apply a 1 kHz sine wave signal from a test signal generator having less than 0.5% total harmonic distortion at the input tested, at a level required to produce full amplifier output. Note that a pad with 150-ohm output impedance is required for driving the microphone level input in accordance with the EIA standard.
   d. Use a distortion analyzer to measure the output level and total harmonic distortion of the audio equipment. In the absence of a distortion analyzer, a high input-impedance measuring device such as a DMM may be used to measure the output level.
6. Loudspeaker Polarity:
   a. Perform loudspeaker line polarity checks using a polarity tester or use DC source at one end of each line and a voltmeter at the other end. Confirm that loudspeaker lines are correctly polarized with respect to color coding.
   b. Confirm loudspeaker polarity using a polarity tester.
7. Freedom from Parasitic Oscillation and Radio Frequency Interference:
   a. With systems set up for each mode of operation specified in the Part 1, confirm that systems are free from spurious oscillation and radio frequency pickup, in the absence of audio input signal and when the system is driven to full output at 100 Hz.
   b. Confirm these tests audibly and by using an oscilloscope having at least 5 MHZ bandwidth.
   c. Apply a slow sine wave sweep from 50 Hz to 5 kHz at a level of 6 dB below rated power amplifier output to each system. Listen carefully for buzzes, rattles and objectionable distortion.
   d. Correct causes of these defects unless the cause is clearly from other than the sound amplification system's equipment and installation, in which case bring the cause to the attention of the Owner and Architect.
8. Audio Test Signal Paths: Verify operation from source inputs through system components to signal destinations.

F. Analog Composite Video Systems:
   1. Signal to noise: Operate the system using an RS-170A test signal. Measure and document output noise levels using a composite video distortion analyzer.

2. Differential gain: Using an RS-170A step test signal and a waveform monitor, measure chrominance, luminance, and normal synchronizing and blanking signals. Measure variations in chroma subcarrier amplitude at 10%, 50%, and 90% luminance.
3. Differential phase: Operate the system as indicated above and measure chroma subcarrier phase variations at 10%, 50%, and 90% luminance.

G. Projection Systems:
1. For each projection system, measure light intensity at the screen's center and four corners. Take corner measurements 5% of the image area width and height in from image edges.
2. Use a properly calibrated foot-candle (or lux) meter with cosine correction for the above measurements.

H. Control Systems:
1. Verify all operational functions at each fixed control interface position.
2. Verify all operational functions of provided wireless control devices.
3. Verify all operational functions of the control system and interfaced devices.

3.10 CLEANING, PROTECTION AND REPAIR

A. Comply with the cleaning requirements of section 270000.

B. During the installation and up to the date of final acceptance, protect finished and unfinished work against damage and loss. In the event of such damage or loss, replace or repair such damaged work.

3.11 SUBCONTRACTOR MANAGEMENT

A. Continuously supervise subcontractors during the installation; intermittent supervision is not acceptable.

3.12 SYSTEM ACCEPTANCE TESTS

A. Perform system acceptance tests after completion of initial system checkout and after submitting the Initial Testing and Tuning Report.

B. Prior to setting up a demonstration and/or punch walk with the Engineer, ensure that the System/Systems are complete, operational, and fully functioning, and that pre-functional and functional testing have been completed. Fees for any additional punch walks resulting from incomplete and/or non-functioning Systems may be assessed.

C. System acceptance tests consist of the following:
1. Take a physical inventory of equipment on site and compare it to equipment lists in the contract documents.
2. Demonstrate the operation of system equipment.
3. Perform both subjective and objective tests to determine compliance with the specifications. Provide test equipment specified for these tests.
4. Provide final, "as built" drawings, run sheets, manuals, and other required documents, as detailed in Part 1.
5. Provide complete testing reports generated by subsystems that provide self-testing.
6. Perform power on/off cycles to ensure these take place with no audible and only minimally visible artifacts, pops, etc.

D. Initial Testing and Tuning Report
   1. Perform the following tests for each system unless otherwise noted in Part 1.
   2. Use additional pages as necessary to allow complete comments.
   3. Where blanks are provided in the checklist below, observe the associated value in parenthesis.

Test	Description	Result	Comment
1	Record equipment that was specified but is not present. Provide a reason why this equipment is not present.		
2	Confirm no sharp or jagged surfaces are accessible to users and technicians.		
3	Confirm that each active device's external temperature, measured using a non-contact thermometer, is within manufacturer's guidelines.		
4	Perform and log cable inspection. Confirm each cable is labeled, dressed, included in a bundle with cables with like signals, not under stress, is serviceable, is correctly strain-relieved, is not bent beyond manufacturer's recommended bend radius, does not have tie wraps tensioned excessively or used inappropriately. Confirm labels are positioned and oriented consistently and are legible and unambiguous.		
5	Demonstrate that the full inventory is new equipment, in full compliance with the specification, or as modified by approved submission. Record test results as pass/fail, and list exceptions.		
6	Confirm rack elevation and single-line drawings, cable and other labels and engravings are an accurate model of the furnished system, and comply with latest revised specifications. Record test results as pass/fail.		
7	Confirm switcher inputs and outputs are labeled (wherever possible), so that users can easily make manual routes quickly without having to refer to the system drawings.		
8	Confirm amplifier channels are properly labeled, so technicians can make quick adjustments without having to refer to the system drawings.		
9	Confirm rack mounted equipment is labeled and that the labels match those on the drawings (equipment symbols and/or description), control system, field plates, patch panels, and any labels associated with the system.		
10	Confirm modular terminations are solid in their connectors.		
11	Confirm each coax cable respects the manufacturer’s minimum bend radius or at least 5x the cable’s diameter.		

Test	Description	Result	Comment
12	Record ambient noise, A-weighted, slow.		
13	Confirm power amplifiers are working within rated load. *Record the impedance (and at what frequency) of each loudspeaker line on each power amplifier at 63, 250, and 1,000 Hz.*		
14	Using appropriate test signals, have the sound system produce a nominal operating level of __(65) dB SPL for conference speech, __(60) dB SPL for program material, “A” weighted at all listeners’ ears ±__(2) dB ("Uniformity of Coverage") (or at least __(15) dB above the ambient noise, A-weighted, whichever is greater), with the control system volume control indicating "normal" or default setting. *Record results for each channel and source.*		
15	Confirm the system is capable of producing an additional __(15) dB above this level (__(80) dB SPL) for each audio source, with less than 0.5% THD (Total Harmonic Distortion) plus noise. *Measure THD plus noise when source is at __(15) dB above nominal operating level at each “destination”, for all sources selected.*		
16	Confirm the system develops a noise level that is electrically __(55) dB below the normal operating level for all audio sources. “Noise” refers to the aggregate of hum, electrostatic noise, RF interference, etc. *Measure and record Signal to Noise (“signal” measured electrically at nominal operating level at each destination, for all sources selected.*		
17	Confirm program loudspeakers are connected in the same polarity, and speech reinforcement systems are polarized such that a positive acoustic pressure on a microphone results in a positive acoustic pressure at the loudspeaker (“Polarity Test”).		
18	Confirm the system produces no more than a __(1) dB variance in program source levels when each program source is playing audio from a calibrated medium (CD, test signal generator, etc.)		
19	Confirm there is no audible vibration caused by improper mechanical installation. *Use a continuous sweep signal at headroom level (from an audio test signal generator or test CD.) Provide a pass/ fail result and document which device fails and the frequency of these artifacts.* (“Buzzes and Rattles Test”).		

Test	Description	Result	Comment
20	Confirm speech reinforcement systems are stable, with no ringing nor feedback.		
21	For audio conference systems, adjust microphone input gain to demonstrate that a "standard talker" (60 dB SPL at 1 m), positioned at each talker position in the room, produces a 0 dB level at the input of the mixer bus of the audio conference DSP device. If there is local voice reinforcement ("mix-minus"), AGC and ALC may need to be restricted when performing this test. *Record test results as pass/fail. Record level across analog telephone line, if one is used. Inspect DSP mixer telephone line levels, both transmit and receive, when normal speech is encountered in the room.*		
22	For conferencing mode, at the __(65) dB SPL listening level, confirm full duplex operation, with no reports of echo or “speech trails” as detected from the far end.		
23	Confirm equalizers, whether hardware or virtual, are adjusted for best intelligibility, and in accordance with any preferred acoustic level response curves. *Record the “house curve” before equalization, as well as after the equalizers have been tuned, with and without microphone input filters. If requested by the Consultant, produce this documentation for systems without equalizers, as this test may apply to the preamp filter settings in cases where intelligibility can be improved.*		
24	If required, confirm system intelligibility, with a RSTI (Rapid Speech Transmission Index) greater than 0.85.		
25	For wireless microphone systems, with all wireless microphones turned on, confirm that throughout the specified operating area for the transmitter, there are no dropouts, intermodulation interactions between wireless systems, nor RF-caused artifacts.		
26	If required, for composite video sources, connect a test generator at each input and confirm 1 volt peak-to-peak to each destination ± 10% (or 1dB). R*ecord results at each destination using NTSC/PAL bars, peak white, and five-step multiburst (0.5, 1.0, 2.0, 3.0, 3.58, and 4.2 MHz).*		
27	For NTSC sources, confirm optimum brightness, contrast, and color in displays using a SMPTE source with PLUGE display.		

Test	Description	Result	Comment
28	Where several displays are visible in the same space, confirm picture tonal consistency across all of them. For composite video signals, use NTSC color bars with PLUGE signal to all. For digital video signals use a colorimeter and test color signal software to confirm consistent images		
29	Confirm projectors are focused, centered, and evenly illuminated. *If requested, confirm using a calibrated light meter that the brightest measurement locations are no more than +10% above average, and the dimmest locations no less than –5% below average measurement. If requested, document that geometric distortion is within 2% tolerance. Take actual measurements if necessary (top, bottom, left, right dimensions of white portion of screen) and photograph if necessary.*		
30	Confirm that the system displays with stability, and with no scaling-related visual artifacts when switching between, at a minimum, the resolutions specified in 1.04 D. Record test results.		
31	Where HDMI, DVI, or DisplayPort signals are included in the system, confirm that an acceptable signal is being displayed on the monitor from each source position. Use the Alt Pixel test image (pixel-on, pixel-off) for each resolution included in the design intent: 1,920x1,200@60, 1,920x1,080@60, 1,280x720@60, as required. Inspect each, leaving the signal on for three minutes. Confirm that no artifacts are visible. For systems including 4k displays, test also at 3,840 x 2,160 and 4,096 x 2,160. Note: If the signal is going to a codec, disable HDCP. If the signal is going to a display, enable HDCP unless specified otherwise in Part 1.		
32	Using a signal generator, confirm scaler and display/projector configurations by successfully passing video at the resolutions defined in 1.04 D.		
33	Confirm HDCP is maintained from sources to destinations except as excluded above. Confirm EDID is managed correctly and that devices output at resolutions supported by the system.		

Test	Description	Result	Comment
34	Confirm the control system controls all of the required equipment as specified. Confirm system performs with stability and in sync with the equipment being controlled without the need to reset any item of equipment. Confirm that user interface requirements dictated in Part 3 of the audiovisual specifications have been met.		
35	Confirm system is serviceable: all devices must be easily removable for repair by one person; all cables must be dressed neatly and be provided with adequate services looks, must be bundled in forms (refer to “Sound System Engineering”, Davis and Davis, 1987 and “Audio Systems Design and Installation”, Giddings, 1990) having no excessive pressure on cables at termination points and connectors, and each cable number must agree with the shop drawings and cabling run list.		
36	Confirm switches and receptacles are logically and permanently labeled.		
37	Confirm nomenclature for consistency: drawings, touch screen, wall plates, floor boxes, patch panels, equipment, etc.		
38	Confirm patch cables have cable numbers.		
39	Where cameras are included in system, confirm each operates correctly and provides correct image quality.		
40	Confirm camera presets are programmed as specified by the user. In the absence of Owner direction, create and document presets that are logical for the room’s layout.		
41	Confirm TV reception from all sources (OTA, CATV, etc.) and that all channel presets are accurate.		
43	Confirm and document the IP configuration information provided by the Owner is loaded into the equipment, including IP and MAC addresses, Dante device names, subnet masks, gateways, time server, gatekeeper, etc. Confirm that all network functions specified by the customer function properly on the customer's LAN.		
44	Confirm all web-based system control and monitoring features, and other IP system functionality (time servers, system-generated e-mail, etc.) are completely functional.		
45	Confirm that display devices have On-Screen Displays/Menus disabled. If the customer has directed otherwise, document from which person this direction came.		

Test	Description	Result	Comment
46	Confirm that video projectors have blue screens or other images or colors displayed in the absence of an input signal disabled. If the customer has directed otherwise, document from which person this direction came.		
47	Log test conference calls (audio and video). Include in the log start time, line used, number called, status of connection (completed/failed, etc.) who was spoken with at the far end, success of full duplex, success of auto-disconnect, dB SPL in the room. Note static, jitter/packet loss, or any other artifacts, distortion, etc. Note if auto-disconnect functions as specified.		
48	Using a full-screen white test signal, confirm no direct view display nor projector has more defective pixels than specified in Part 1. Note number and location of lost pixels, if any. Provide photos of defects. Include room numbers and any other distinguishing information in photo file names.		
49	Check for excessive vibration on VC camera(s) at full telephoto position.		
50	Provide video recordings of all non-conformances and anomalies.		
51	Confirm all visible devices are installed square and plumb.		
52	Confirm no dust, grease, scratches, or any other signs of handling are visible on any devices		
53	Confirm assistive listening systems work throughout intended listening areas		
54	Confirm closed captioning is functional on all displays		
55	Confirm control system user interfaces provide a means to enable and disable display of closed captions		

E. If further adjustment is required, or defective equipment must be repaired or replaced, tests may be suspended or continued at the option of the Owner or Owner's representative.
   1. If the need for further adjustments becomes evident during the demonstration and testing, continue work until the installation operates properly. Included in the continued work, changes to or installation of resistive pads, adjustment of loudspeaker aiming, adjustment of system processing, programming changes to the control system, convergence and/or alignment of the video projector, if these adjustments are required.
   2. If acceptance of the system is delayed because of defective equipment or because the equipment does not fulfill this specification, reimburse the Owner for time and expenses for these tests during extensions of the acceptance testing period.

3.13 OWNER TRAINING

A. Provide a minimum of 16 hours of training on the audiovisual systems specified herein at the project site (or other location designated by the Owner) by a qualified instructor (equipment manufacturer as needed) covering operation and maintenance of the systems.

3.14 MAINTENANCE AND EXTENDED SERVICE

A. Warranty Maintenance
   1. On a quarterly basis during the warranty period, execute a service visit to check and adjust equipment and systems such that they maintain the original performance. Coordinate visits directly with the Owner.
   2. Pre-emptive Maintenance Minimum Requirements:
      a. Clean filters, vents, and lenses, and dust the equipment.
      b. Verify projector images fill screens appropriately and images are focused.
      c. Test and verify that all system controls operate as labelled and that the controlled devices respond accordingly.
      d. Document and photograph any conditions that may affect the continued function and long-term operation of the audiovisual system and report to owner.
      e. Document and report projector lamp life to the Owner and replace lamps as directed.

B. Provide cost for additional service levels beyond the warranty period (as defined in this section) as follows:
   1. One year, two-year, and three-year service with quarterly pre-emptive maintenance calls and same-day issue response
   2. One year, two-year, and three-year service with quarterly pre-emptive maintenance calls and 24-hour issue response
   3. One year, two-year, and three-year service with quarterly pre-emptive maintenance calls and 48-hour issue response

C. Touch Panel Programming Updates
   1. At a date determined by the Owner within six months following Substantial Completion, attend a single meeting with them regarding alterations or updates to the touch panel layouts or function. At a time approved by the Owner, implement those alterations or updates.
   2. Provide any training necessitated by these revisions.
   3. Provide documentation of these revisions to the Engineer.
   4. Provide the source code documentation according to “Software License” in this section.

END OF SECTION 27 41 16

SECTION 28 00 00

BASIC SECURITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general administrative and procedural requirements for division 28 sections and supplements the requirements specified in Division 1.

B. The requirements described herein include the following:
1. References
2. Definitions
3. System Description and Existing Conditions
4. Submittals
5. Quality Assurance
6. Permits and Inspections
7. Coordination
8. Project Management and Coordination Services
9. Product Delivery, Storage, and Handling
10. Warranty
11. Maintenance

C. Products Supplied But Not Installed Under This Section:
1. None

D. Products Installed But Not Supplied Under This Section:
1. None

E. Products Specified But Not Installed Under This Section:
1. None

F. Products Furnished and Installed Under another Section:
1. 120V power
2. Conduit, junction boxes, device boxes (essentially rough-in)
3. Door hardware
4. Network cabling and equipment

G. Related Sections:
1. Consult other sections, determine the extent and character of related work, and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation.
2. Section 260533, “Raceway and Boxes for Electrical Systems”
3. Section 270528, “Pathways for Communications Systems”
4. Section 280513, “Security System Cabling”
5. Section 280553, “Security System Labeling”
6. Section 280800, “Security System Acceptance Testing”
7. Section 281300, “Access Control and Alarm Monitoring System”
8. Section 282300, “Video Surveillance System”
9. Section 284619, “PLC Detention Monitoring and Control System”

10. Section 142000, “Elevators”
11. Earthwork: Include trenching, backfilling, boring and soil compaction as required for the installation of underground conduit, in-grade pull boxes, vaults, and bollard foundations.
12. Selective Demolition: Nondestructive removal of materials and equipment for reuse or salvage as indicated. Also dismantling electrical materials and equipment made obsolete by these installations.
13. Concrete Work: Include forming, steel bar reinforcing, cast-in- place concrete, finishing and grouting as required for underground conduit encasement, pedestal foundations, and curbs. [Also includes saw-cutting of existing slabs and grouting of conduits in saw-cut.]
14. Miscellaneous Metal Work: Include fittings, brackets, backing, supports, rods, welding and pipe as required for support and bracing of raceways, equipment enclosures, cameras, and similar devices.
15. Miscellaneous Lumber and Framing Work: Include wood grounds, nailers, blocking, fasteners, and anchorage for support of security materials and equipment. Refer to Division 6, Rough Carpentry.
16. Moisture Protection and Smoke Barrier Penetrations: Include membrane clamps, sheet metal flashing, counter flashing, caulking and sealant as required for waterproofing of conduit penetrations and sealing penetrations in or through fire walls, floors, ceiling slabs and foundation walls. Tape and make vapor tight penetrations through vapor barriers at slabs on grade.
17. Division 8 Locking Hardware: Include interface to electronic hardware and door controllers on security related doors.
18. Access Panels and Doors: Required in walls, ceilings, and floors to provide access to security devices and equipment.
19. Painting: Include surface preparation, priming and finish coating as required for security cabinets, exposed conduit, pull and junction boxes, and devices where indicated as field painted in this Division.

1.2 REFERENCES

A. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies mean that latest edition of such publications adopted and published prior to submittal of the bid. Consider such codes or standards a part of this Specification as though fully repeated herein.

B. Codes: Perform work executed under this section in accordance with applicable requirements of the latest edition of governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:
   1. California Code of Regulations (CCR):
      a. Title 8, “Industrial Relations”
         1) Chapter 3.22, “California Occupational Safety and Health Regulations (CAL/OSHA)”
      b. Title 24, “California Building Standards Code”
         1) Part 1, “California Building Standards Administrative Code”
         2) Part 2, Volumes 1 and 2, “California Building Code” (CBC)
         3) Part 3, “California Electrical Code” (CEC)
         4) Part 11, “California Green Building Standards Code” (CALGeen)”
   2. National Fire Protection Agency (NFPA)
      a. NFPA 70, “National Electrical Code” (NEC)
      b. NFPA 75, “Protection Of Information Technology Equipment”
      c. NFPA 262, “Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces”, 2007

3. Code of Federal Regulations (CFR) Title 47 “Telecommunication”, Chapter I “Federal Communications Commission (FCC)”:
   a. Part 27, “Miscellaneous Wireless Communications Services”
4. Other applicable national, state, and local binding building and fire codes

C. Standards: Perform work and furnish materials and equipment in accordance with the latest editions of the following standards as applicable:
1. Underwriter's Laboratories (UL): Applicable listing and ratings.
   a. UL 294, “Access Control System Units”
   b. UL 1076, “Proprietary Burglar Alarm Units and Systems”
   c. UL 2044, “Commercial Closed-Circuit Television Equipment”

1.3 DEFINITIONS

A. The Definitions of Division 1 apply to the sections of Division 28.

B. In addition to those Definitions of Division 1, the following list of terms as used in this specification defined as follows:
1. “ACAMS”: Access Control & Alarm Monitoring System
2. “As directed”: As directed or instructed by Owner, or their authorized representative
3. “Cabling”: A combination of cables, wire, cords, and connecting hardware [e.g., cables, conductor terminations, connectors, outlets, patch panels, blocks, and labeling]
4. “Connect”: To install required patch cords, equipment cords, crossconnect wire, etc. to complete an electrical or optical circuit
5. “Engineer”: TEECOM
6. “Furnish”: To purchase, procure, acquire, and deliver complete with related accessories
7. “IDS”: intrusion detection system
8. “Install”: To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test before turning over to Owner, parts, items, or equipment supplied by Contractor or others. Complete installation and make ready for regular operation
9. “Owner”: Laney College
10. “Provide”: furnish and install
11. “Security System”: the ACAMS, IDS, VSS, and Intercom systems collectively and integrated
12. “SEC”: Security Equipment Enclosure
13. “VAC”: volts alternating current
14. “VDC”: volts direct current
15. “VSS”: video surveillance system
16. “VMS”: visitor management system

1.4 SYSTEM DESCRIPTION

A. Overview
1. Laney College is constructing a 3-story multi-level library building.
2. Security at the new facility consists of access control and alarm monitoring (ACAMS), and video surveillance (VSS), intrusion detection (IDS), and intercom systems. The ACAMS will automate opening and closing the buildings, control access through designated doors, and will restrict after-hours access to authorized cardholders, and the IDS will monitor specific spaces for intrusion.
3. The new system will connect to Owner’s exiting head end located in the data center over the Owner’s LAN/WAN.

4. The System includes integration to the Fire/Life Safety system to disconnect power to magnetic door holders and automatically close doors after hours.
5. The System includes elevator security and integration between the electronic security system and elevator controller.
6. Refer to individual sections for detailed description of systems.

B. Custom Device Requirements
1. General: Provide a high level of coordination services to ensure the proper installation and functioning of the security system. Coordinate the installation of the security system with other trades. This may include: review of other trade's shop drawings, attendance at meetings, providing samples for mockup, and preparation & distribution of written documentation.

1.5 SUBMITTALS

A. Submit required submittals in accordance with the requirements of section 013300 "Submittal Procedures".

B. Required submittals include the following:
1. Written detailed project description
2. Project schedule as referenced in this section
3. Product data sheets – clearly indicate by arrows or brackets precisely what is being submitted on and those optional accessories which are included and those which are excluded
4. Estimated delivery lead times for products
5. Voltage drop calculations demonstrating less than ten percent voltage loss to individual security devices
6. Battery calculations showing backup support of security equipment and locks (except egress hardware with local power supplies) for 25 lock activations or 4 hours, whichever is greater

C. Complete submittals are comprised of shop drawings and product data sheets as detailed below and related sections (covering specific security systems). Incomplete or partial submittals will be rejected.

D. Shop Drawings
1. Shop drawings shall document Contractor's intent to execute the work and shall include the following:
    a. Title sheet and index
    b. Floor plans showing device locations, cable routing, and pathways
    c. System block diagrams
    d. Point-to-point wiring diagrams
    e. Specific wiring details and device mounting/installation details
    f. Schedules:
        1) Building/floor
        2) Unique device name/number
        3) Security controller/location
        4) Interfaces, interlocks
        5) IP address
        6) Master/substation intercom calling locations
2. Upon award of contract, request CAD release forms from TEECOM so that electronic files may be released for Contractor's use. TEECOM will release floor plans with devices;

TEECOM will not installation details and block diagrams (Contractor shall develop their own diagrams and details for the shop drawings submittal package).

E. Format: Furnish submittal data in electronic copy including table of contents with each section bookmarked by specification section listing materials.

F. Label each submittal with the specification section number and provide a cover letter or stamp stating that the submittal has been thoroughly reviewed by Contractor and complies with the requirements of the contract documents. Failure to comply with this requirement will constitute grounds for rejection of the submittal.

G. Resubmittals: Provide a cover letter with the resubmittal that lists the action taken and revisions made to each product submittal in response to submittal review comments. Failure to include this cover letter will constitute rejection of the resubmittal package and no review will occur.

H. Drawings
   1. Prepare shop and as-built drawings using software compatible with AutoCAD and/or Revit per project standard.
   2. Drawing requirements:
      a. Sheet size: match the project's contract drawings size and use the project's title block
      b. Text size: minimum 3/32 inches high when plotted at full size
      c. Symbology: match the project's contract drawings symbols
      d. Backgrounds: screen background information to allow pertinent drawing information to stand out.
      e. Line Weights: Use appropriate line weights for devices, raceways, and text to stand out against background information.
      f. Floor Plans: 1/8 inch scale floor and site plans showing the locations of devices and cable routing paths with cable types and quantity called out.

I. Contractor Qualifications: Submit the following for review and comment at the beginning of the project.
   1. Resumes of the project manager, general foreman, and lead technician(s) indicating role, years of experience, product certifications and training, listing of similar projects the individual performed the role proposed for this project along with client contact information for each.
   2. Certification letters from manufacturers of major system components stating Contractor is an authorized reseller, installer, and extended warranty provider for the specified security systems.

J. Samples
   1. Submit samples as required for proper coordination and installation of custom mounted equipment. Examples of samples that may be required include:
      a. Screen shots showing graphical floor plan maps indicating:
         1) Active functional icons
         2) Secure areas/zones
      b. Camera field of views

1.6 QUALITY ASSURANCE

A. General
   1. Provide new and unused materials, equipment, and parts comprising the units specified herein of current manufacturer and of highest grade.

2. Only use products and applications listed in this Division on the project.

B. Bid Discrepancies
   1. In the event of discrepancies within the contract documents, notify Engineer within 5 days prior to the bid opening to allow the issuance of an addendum.
   2. If, in the event that time does not permit notification or clarification of discrepancies prior to the bid opening, the following applies: The drawings govern in matters of quantity, and the specifications govern in matters of quality. In the event of conflict within the drawings involving quantities, or within the specifications involving quantities, or within the specifications involving quality, the greater quantity and higher quality apply. Note such discrepancies and clarify in the bid. We will make no additional allowances because of errors, ambiguities, or omissions, which reasonably should have been discovered during the preparation of the bid.

C. Substitutions
   1. Conform to the general requirements and procedure outlined in section 012500 “Substitution Procedures”.
   2. Where products are noted as “or equal”, a product of equivalent design, construction, and performance is considered. Include in the product data submittal: catalog cuts, product information, and pertinent test data required to substantiate that the product is in fact equivalent to that specified.
   3. Only one substitution allowed for each product specified. Do not provide substituted material, processes, or equipment without written authorization from Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by Engineer, are at the sole risk of Contractor.
   4. The burden of proof rest with Contractor that the substituted product is equivalent or better than the specified product. When Engineer accepts a substitution in writing, it is with the understanding that Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Approved substitutions do not relieve Contractor of responsibilities for the proper execution of the work, or from provisions of the Specifications.
   5. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance. Materials, processes or equipment that, in the opinion of Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when “or equal” follows the manufacturers' names or model number(s).
   6. Whenever material, process or equipment is specified in accordance with a Federal specification, an ASTM standard, an ANSI specification, UL rating or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by Engineer, submit support test data to substantiate compliance at no additional cost.
   7. Pay expenses, without additional charge to Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on self, Subcontractor's or other Contractor's work.

D. Electronic Control Systems Contractor Qualifications
   1. A current, active, and valid and C7 or C10 license registered with the Contractors State License Board (CSLB)
   2. Minimum five years of experience in installation and service of access control, video surveillance, and intrusion detection systems
   3. Minimum five completed projects similar to scope and cost

4. Evidence of technicians qualified for the work in the form of current manufacturer's training certification

E. Materials
1. Provide new materials and equipment without defects.
2. Provide only specified products and equipment, or products and equipment that have been approved in writing.

F. Regulatory Requirements
1. Work and materials to conform to the latest rules of National Board of Fire Underwriters wherever such standards have been established and to the regulations of the State Fire Marshal, OSHA and the codes of the governing local municipalities. Perform work under these specifications confirming to the most stringent of the applicable codes.
2. Provide the quality identified within these specifications and drawings when codes, standards, regulations, etc. allow Work of lesser quality or extent. The contract documents address the minimum requirements for construction.

G. Drawings
1. Layout: Follow the general layout shown on the contract drawings except where other work may conflict with the contract drawings.
2. Accuracy: The contract drawings show a diagrammatic representation of the system within the constraints of the symbology applied.
3. Detail: The contract drawings represent the design intent and do not represent the entire installation for the System. Contract drawings indicate the layout and location of control panels, devices (i.e. card readers, door locks and contacts, and duress stations) and other components. The contract drawings do not show conduits, wire and cabling between every system component, equipment, or device.
4. Complete the details necessary for point-to-point design. This allows the Contractor to attain the design intent while applying their own means and methods.

H. Role of Engineer
1. During the construction phase of the project, Engineer will work with Contractor to provide interpretation and clarification of project contract documents, process and reply to relevant Requests for Information (RFI), and act as an interface between Contractor and Owner.
2. Owner has retained Engineer's services to observe the work for general compliance with the contract documents.
3. In summary, Engineer will perform the following specific services during the design phase:
    a. Review product submittals and shop drawings for general compliance with the contract drawings and specifications.
    b. Review changes as they arise and confirm that the proposed solutions maintain the intended functionality of the system.
    c. Interpret field problems for Owner and translate into understandable language.
    d. Review the testing procedures to confirm compliance with industry-accepted practices.

1.7 PERMITS AND INSPECTIONS

A. Obtain and pay for permits and inspections required for the work.

B. Furnish materials and workmanship for this work in conformance with applicable legal and code requirements.

C. Perform tests required herein, or as may be reasonably required to demonstrate conformance with the Specifications or with the requirements of legal authority having jurisdiction.

D. Obtain review from compliance officials responsible for enforcement of applicable codes and regulations to establish that the work is in compliance with requirements of reference codes indicated herein.

1.8 PROJECT MANAGEMENT AND COORDINATION SERVICES

A. Provide a project manager for the duration of the project to coordinate the security system work with other trades. Coordination services, procedures and documentation responsibility include at a minimum, the items listed in this section.

B. Review of Shop Drawings prepared by Other Subcontractors:
   1. Obtain copies of shop drawings for equipment and systems provided by others that require connections or interface with the security system work. Thoroughly review those shop drawings to confirm compliance with the interface requirements.
   2. Document discrepancies or deviations:
      a. Prepare memo summarizing the discrepancy.
      b. Submit a copy of the specific shop drawing, indicating via cloud, the discrepancy.
   3. Prepare and maintain a shop drawing review log indicating the following information:
      a. Shop drawing number and brief description of the system/material.
      b. Date of your review.
      c. Indication if follow-up coordination is required.

C. Scheduling: Prepare work schedules for each floor indicating the following information:
   1. Submittals
   2. Cable Installation
   3. SEC Build Out
   4. Device Installation
   5. Programming
   6. Testing
   7. Training
   8. Other tasks included under the alternate work section of these specifications

D. Job Conditions
   1. Protection: Keep conduits, junction boxes, outlet boxes and other openings closed to prevent entry of foreign matter. Cover equipment, devices, and apparatus to protect them against dirt, paint, water, chemical or mechanical damage, before and during construction period. Prior to final acceptance, restore to original condition fixture, apparatus or equipment damaged including restoration of damaged factory applied painted finishes. Protect bright finished surfaces and similar items until in service. No rust or damage will be permitted.
   2. Supervision: Personally, or through an authorized and competent representative, supervise the work from beginning to completion and, within reason, keep the same foreman and workmen on the project throughout the project duration.

E. Weekly Status Reports: Prepare weekly status reports throughout the entire course of the project containing the following information:
   1. Current / up-to-date 2-week look ahead schedule
   2. Progress during prior week
   3. Work expected to be completed during the upcoming week
   4. Delivery dates for equipment

5. Coordination status for each device requiring coordination with other subcontractors
6. Summary of the information owed to Contractor, who is responsible for providing the information, and due date for the information

F. Weekly Meetings: Conduct or attend weekly coordination meetings with the electrical and other specialty subcontractors to coordinate the installation of the security systems.

1.9 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery
1. Do not deliver security system components to the site until protected storage space is available.
2. Replace equipment damaged during shipping and return to manufacturer at no cost to Owner.

B. Storage
1. Store materials in a clean, dry, ventilated space free from temperature extremes. Storage outdoors covered by rainproof material (for example, a tarp) is not acceptable.
2. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.
3. Provide heat where required to prevent condensation or temperature related damage.

C. Handling
1. Handle in accordance with manufacturer's written instructions.
2. Prevent internal component damage, breakage, denting and scoring. Do not install damaged equipment. Replace damaged equipment and return equipment to manufacturer.

1.10 WARRANTY

A. Provide the Security System as described in this specification with a one-year parts and service warranty at no additional cost to Owner.

B. Include in the warranty package, at a minimum, the following:
1. Emergency maintenance service on regular working hour basis
2. Service by factory trained and employed service representatives of system manufacturer

C. Maintain regular service facilities and provide a qualified technician familiar with this work at the site within four hours of receipt of a notice of malfunction including weekends and holidays. Provide material, devices equipment and personnel necessary for repairs. Install approved temporary, alternate equipment if required by Owner, complete and operational within 24 hours after notification of a malfunction, at no additional cost.

D. Conduct warranty repairs and service at the job site unless in violation of manufacturer's warranty; in the latter event, provide substitute systems, equipment and/or devices, acceptable to Owner, for the duration of such off-site repairs. Transport warranty substitute and/or test systems, equipment, devices, material, parts and personnel to and from the job site at no additional cost.

E. Warranty period shall commence upon written final acceptance by Owner or Owner’s designated representative.

1.11 MAINTENANCE

A. Extra Materials
   1. Deliver extra materials to a secured location determined by Owner.
   2. Provide a complete bill of materials listing quantities, part numbers, and descriptions for each device for Owner to sign indicating receipt of equipment.
   3. Provide new and unused spare parts in their original packing materials upon delivery.

B. Maintenance Service
   1. For the first year of service, conduct quarterly system performance review meetings to review system operation problems and/or defects that occurred during the preceding 3 months. During these performance review meetings, perform the following:
      a. Visual checks and operational tests of the central processor, local processors, monitors, keyboards, system printers, peripheral equipment, security equipment and devices, power supplies, and electrical and mechanical controls.
      b. Clean system equipment, including interior and exterior surfaces.
      c. Perform diagnostics on equipment.
      d. Check and calibrate each device.
      e. Run system software and correct diagnosed problems.
      f. Resolve previous outstanding problems.
   2. Provide software and firmware updates issued free of charge by the manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL

A. Material and equipment specified herein have been selected as the basis of acceptable quality and performance and have been coordinated to function as components of the included systems. Where a particular material, device, equipment or system is specified directly, the current manufacturer's specification for same is a part of these specifications, as if completely elaborated herein.

B. Use standard, regularly manufactured, materials and equipment for this and/or other similar systems, and not custom designed especially for this project. Provide systems and components thoroughly tested and proven in actual use. Provide subsystems of one manufacturer.

2.2 EQUIPMENT ENCLOSURES AND JUNCTION ENCLOSURES

A. Application: For indoor use to house panels and equipment, and to house terminations, relays, and other components local to controlled doors and other field devices

B. Type: NEMA type 1 enclosure

C. Description:
   1. Solid steel enclosure with solid, continuous-hinged door
   2. Finish: ANSI 61 gray polyester powder paint finish inside and out
   3. Lockable / equipped with a lock kit (lock kits shall be keyed alike with other security enclosures throughout the project)
   4. Perforated back panel within enclosure (for mounting control boards, relays, terminal strips, etc.)
   5. One tamper switch per enclosure

6. One 5” electric fan with a screen at the port per enclosure that houses electrically-powered devices/equipment

D. Size:
1. For use as Security Equipment Enclosure: 36"L x 24"W x 6"D minimum
2. For use as Security Junction Enclosure: 12"L x 12"W x 6"D minimum

E. Manufacturer, or equal:
1. Eaton Cooper B-Line
   a. #36246-1PP; 36"L x 24"W x 6"D enclosure with back panel and lock kit
   b. #12126-1PP; 12"L x 12"W x 6"D enclosure with back panel and lock kit
2. Hoffman
   a. #A36N24M; 36"L x 24"W x 6"D enclosure
   b. #A36N24MPP back panel for 36" x 24" enclosure
   c. #A12N126; 12"L x 12"W x 6"D enclosure
   d. #A12N12PP; back panel for 12" x 12" enclosure
   e. # AL12AR; lock kit
3. Wiegmann
4. SquareD

2.3 SLOTTED WIRING DUCT

A. For indoor use inside equipment enclosures to manage/mind wiring.

B. Description:
1. Type: Lead-free PVC with narrow finger design
2. Color: Light gray

C. Manufacturer, or equal:
1. Panduit Type-F narrow slot wiring duct
2. Iboco #T1-1010 wiring duct

2.4 WIREWAYS

A. For indoor use with equipment enclosures to manage and route wiring and cabling.

B. Type: NEMA type 1 screw cover ‘gutter’ wireway and accessories

C. Description:
1. Wireways shall have open top assembly and closure plates/end caps (to secure end of wireway sections).
2. Finish: ANSI 61 gray polyester powder paint finish inside and out
3. Size: 4" x 4", minimum

D. Manufacturer, or equal:
1. Eaton Cooper B-Line #4448-G-NK; lay-in painted wireway without knockouts
2. Hoffman #F44T148GVP lay-in painted wireway without knockouts

2.5 INTERFACE RELAYS

A. Application: lock power switching and interfacing with other high-voltage powered equipment, i.e. gates, high-voltage locks, etc. (not for use at the output contacts on the access controllers since their rating is not adequate)

B. Type: Standard industry control, plug-in type with LED indicator lights to indicate when the relay is energized.

C. Contacts: Rated for 10 amps at 120VAC.

D. Coil Operating Voltage: as required, with 24VDC as first choice

E. Features:
   1. Color-coded test button
   2. Mechanical flag
   3. Snap-on label
   4. Pilot light
   5. 2mm test jacks
   6. Dual contact markings
   7. Snap-on number and letter markers
   8. Solid bus-bar socket construction

F. Relay bases shall be mountable on standard mounting rails

G. Manufacturer, or equal:
   1. Releco
   2. Idec

2.6 TAMPER RESISTANT HARDWARE

A. Tamperproof hardware shall be used in locations below 10' exposed to the public.

B. Hardware exposed in public spaces shall be pinned-allen type.

C. Hardware used in specialty metal surfaces shall have a similar finish color.

2.7 WIRE CONNECTORS

A. Wire connectors shall be heat activated, gel filled.

B. Twist and solder/taped or wire nut connections are not acceptable.

C. Manufacturer, or equal:
   1. Dolphin
   2. 3M Terminals
   3. Fastenal Sealed Crimp and Solder connector

PART 3 - EXECUTION

3.1 EXAMINATION

A. Conditions: Verify existing conditions, which have been previously provided under other sections, are acceptable for product installation in accordance with manufacturer's instructions.

B. Pathways: Verify that pathways and supporting devices, which have been previously provided under other sections, are properly installed, and that temporary supports and devices have been removed.

C. Field Measurements: Verify dimensions of pathways, including length of pathways. For example, “True Tape” the conduits to verify cable distances.

3.2 FIELD QUALITY CONTROL

A. Staffing: Provide a qualified foreman who is in charge of the work and who is present at the job site at times work is being performed. Perform the work using skilled technicians under the direction of the foreman. Supervise the work force executing the work. Perform the installation within the restraints of the construction schedule. Do not change the supervisor during the project without prior written approval from Owner.

B. Inspection: Perform inspection after installation. Keep areas of work accessible and notify code authorities, or designated inspectors, of work completion released for inspection. Document completion, and inspection as required.

3.3 INSTALLATION

A. Perform this work in accordance with acknowledged industry and professional standards and practices and the procedures specified herein.

B. Provide a complete, operating system. Include devices specified including basic components and accessories, interconnecting wiring and other equipment and installation devices necessary for a complete system as specified.

C. System Password Management:
   1. Change default passwords.
   2. Create a base administrator account for Owner’s use/login.
   3. Install the latest security patches (for the operating system and each individual piece of equipment).
   4. Disable unused communication ports or protocols.
   5. Perform quarterly software security patch updates for the client during the warranty period.
   6. Contractor to turn over all source media including installation discs, manuals, drives, dongles, and licensing keys and codes.

D. Manufacturer's Instructions:
   1. Comply with manufacturer's product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.
   2. Maintain jobsite file of Material Safety Data Sheets (MSDS) for each product delivered to jobsite.

E. Boxes, Panels, and Enclosures
   1. Install boxes, panels, and enclosures square and plumb.
   2. Set flush-mounted units with the face of the cover, bezel, or escutcheon in the same plane as the surrounding finished surface.
   3. Mount boxes, panels, and trim so that there are no gaps, cracks, or obvious lines between the trim and the adjacent finished surface; ready them to receive final finish, as applicable.
   4. Install insulating terminations in signal circuit boxes, panels, wireways, or enclosures.

F. Painting
   1. Custom paint devices as indicated on the drawings.

3.4 REPAIR/RESTORATION

A. Replace or repair work completed by others that you deface or destroy, and at no cost to Owner.

B. Punch List:
   1. Inspect installed work and develop a punch list for items needing correction.
   2. Submit punch list to Engineer for review prior to performing punch walk with Engineer.

C. Re-Installation:
   1. Make changes to the system such that defects in workmanship are correct and cables and the associated termination hardware passes the minimum test requirements.
   2. Repair defects prior to system acceptance.

D. Painting: Repaint surfaces altered during installation of the security system to match previous conditions.

3.5 CLEANING

A. Remove temporary coverings and protection of adjacent work areas. Remove unused products, debris, spills, or other excess materials. Remove installation equipment.

B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.

C. Repair or replace damaged installed products.

D. Legally dispose of debris in an environmentally friendly manner.

E. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.

END OF SECTION 28 00 00

SECTION 28 05 13

SECURITY SYSTEM CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Cables and wires for security systems

B. Related Sections:
1. Consult other sections; determine the extent and character of related work and properly coordinate work executed under this section with that specified elsewhere to produce a complete and operable system.
2. Section 280000, “Basic Security Requirements”
3. Section 280553, “Security System Labeling”
4. Section 260533, “Raceway and Boxes for Electrical Systems”
5. Section 270528, “Pathways for Communications Systems”
6. Section 271513, “Horizontal Cable”

1.2 REFERENCES

A. Comply with the References requirements of section 280000.

B. In additional to those codes, standards, etc., listed in section 280000, products and work shall comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
1. NFPA 262, “Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces”

1.3 SUBMITTALS

A. Submittal Requirements at Start of Construction:
1. Product Data: Submit product information, including manufacturer, part number, description, use/application, jacket rating, outside diameter, etc.

B. Submittal Requirements at Closeout:
1. Include wire and cable types in As-Built Drawings
2. Include wire and cable information in O&M Manuals

1.4 SCOPE OF WORK

A. General: Provide engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working security system installation as described in these specifications.

B. Cables for Security System
   1. Provide wires and cables sized to allow for voltage drop of 12VDC and 24VDC power service from power supplies in equipment rooms to field devices.
   2. Provide cables effectively shielded for video signal cable within the same conduit to mitigate interference or signal noise.
   3. Provide plenum rated jacket (type CL2P, CL3P, or CMP) on cables installed indoors where required.
   4. Provide PVC or PE jacket, flooded cables to prevent water intrusion where installed outdoors, underground, and/or within slab-on-grade. Provide transition of outdoor/underground cables to indoor cables when entering a building.
   5. Provide surge protection when cables enter buildings from outdoors where required by NEC.

C. Cable Supports and Pathways for Security System Cabling
   1. Provide dedicated cable support for security cables when not within primary pathways (such as cable tray). Coordinate work with Division 27 – particularly for use of pathways/cable support.

PART 2 - PRODUCTS

2.1 INDOOR PLENUM MULTI-CONDUCTOR CABLES

A. Application: Indoor use, for ACAMS, and VSS

B. Type: multi-conductor or paired, unshielded and shielded

C. CMP (plenum) rated

D. Manufacturers, or equal:
   1. Belden
      a. #6500UE; 22AWG/2C, unshielded
      b. #6502UE; 22AWG/4C, unshielded
      c. #1325A; 22AWG/2PR, individually shielded
      d. #6502FE; 22AWG/4C, overall shielded
      e. #6504FE; 22AWG/6C overall shielded
      f. #3004A; 22AWG/8C overall shielded
      g. #6300UE; 18AWG/2C, unshielded
      h. #6302UE; 18AWG/4C, unshielded
      i. #6302FE; 18AWG/4C, overall shielded
      j. #6100UE; 14AWG/2C, unshielded
   2. West Penn
      a. #25221B; 22AWG/2C, unshielded
      b. #25241B; 22AWG/4C, unshielded
      c. #D25510B; 22AWG/2PR, individually shielded
      d. #253241B; 22AWG/4C, overall shielded
      e. #253270B; 22AWG/6C overall shielded
      f. #253271B; 22AWG/8C overall shielded
      g. #25224B; 18AWG/2C, unshielded
      h. #25244BI; 18AWG/4C, unshielded
      i. #253244B; 18AWG/4C, overall shielded
      j. #25226B; 14AWG/2C, unshielded

3. Windy City Wire
    a. 444362; 22AWG/2C, unshielded
    b. 444381; 22AWG/4C, unshielded
    c. 4150102; 22AWG/2PR, individually shielded
    d. 4443440; 22AWG/4C, overall shielded
    e. 444351-03; 22AWG/6C overall shielded
    f. 444352-08; 22AWG/8C overall shielded
    g. 442363; 18AWG/2C, unshielded
    h. 442384; 18AWG/4C, unshielded
    i. 442344; 18AWG/4C, overall shielded
    j. 447960; #6100UE; 14AWG/2C, unshielded

2.2 IP CAMERA CABLE

A. Application: Suitable for indoor installation within conduit

B. Refer to Section 271513 for product requirements.

2.3 MISCELLANEOUS COMPONENTS

A. Cable Ties
    1. Width: 0.75 inches
    2. Color: Black
    3. Manufacturers, or equal:
        a. Panduit #HLS-15-R-0 Black, 15 feet roll, cut to length

PART 3 - EXECUTION

3.1 INSTALLATION

A. Cable Installation and Routing
    1. Install cables and wires continuously (splices will not be permitted without written approval from the Engineer) for the entire length of run between connections and/or terminations.
    2. Place and suspend cables within designated pathways, such as cable hangers, cable tray, etc. Do not fasten or attach cables (such as with cable ties) to other building infrastructure (such as ducts, pipes, conduits, etc.), other systems (such as ceiling support wires, wall studs, etc.), or to the outside of conduits, cable trays, or other non-approved pathway systems.
    3. Place and suspend cables during installation and termination in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation or termination at no additional cost.
    4. Route cables at 90-degree angles, allowing for bending radius, along corridors for ease of access.
    5. Route cables under building infrastructure (such as ducts, pipes, conduits, etc.) so the installation results in easy accessibility to the cables in the future.
    6. Do not exceed manufacturer's limits for pulling tension.
    7. Do not use cable-pulling compounds for indoor installations.

8. Dress and secure cables without stress and/or deformation. Dress and bind cabling with cable ties every 24” minimum. Within telecommunications spaces and covered wireways, provide Velco-style cable ties on security cabling.
9. Install shielded wiring or route in separate raceways as recommended by the manufacturer's current requirements.
10. Place cables a minimum of 6" away from power sources to reduce interference from EMI.
11. Do not run signal wire and cable in parallel to power (120VAC).
12. When connecting to screw-type barrier blocks, terminate wires with insulated crimp-type spade lugs. Size lugs properly to assure high electrical integrity, i.e., low resistance connections.
13. Follow manufacturers recommended guidelines for installation.
14. When exiting the primary pathway (such as cable tray) to the device, exit via the top of the pathway. Secure the cables to the pathway using an approved cable tie.
15. When routing cables vertically in conduit for continuous distances greater than 30 feet, secure cables as the cables exit the vertical pathways. Secure cables using screw-flange nylon cable ties or similar approved ties. Provide symmetrical clamping devices with split, circular, or other wire conforming, nonmetallic bushings for coaxial cables.
16. Within telecom rooms, route and dress cables on the overhead cable support and, when routing vertically, fasten the cables onto wall-mounted vertical cable support every 24 inches on-center using cable ties.

B. Cable Support
1. Coordinate cable support work with sections 270528 and 270536 for indoor pathways such as cable hangers.
2. Above ceilings, support cables at intervals no greater than 5 feet.
3. Anchor cable support system/components to structure.
4. Vertical Support on floor space, not in riser system
    a. Route cable from below suspended ceiling devices to above ceiling when possible.
    b. When routing cable in fire-rated wall assemblies, provide conduit and firestopping.
    c. When routing cable on concrete tilt up style walls from below ceiling devices to above ceiling, provide conduit – either surface or recessed (depending on wall construction).
    d. For cable routed vertically from devices with no suspended ceiling, provide conduit stub from device junction box to 14 feet, minimum, above finish floor.
5. Vertical Support in riser system
    a. In vertical riser systems, route cable within conduit.
    b. Terminate conduit at each stacked closet in a lockable junction box. Size junction box as required per conduit size and quantity – 12" x 10" x 8", minimum.
    c. Support cables within the junction box at every other floor or approximately every 24 feet utilizing cable ties equipped with eyelets designed to accept screws for fastening or approved equivalent method.
6. Label cables in accordance with section 280553, “Security System Labeling”.

END OF SECTION 28 05 13

SECTION 28 05 53

SECURITY SYSTEM LABELING

PART 1 - GENERAL

1.1 SUMMARY

A. General: Furnish labor, materials, tools, etc., as required to complete security system labeling.

B. Section Includes:
   1. Labeling of wire, cable, security devices, enclosures, and raceways.

C. Related Sections:
   1. Consult other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable system.
   2. Section 280000, “Basic Security Requirements”

1.2 SUBMITTALS

A. Product Data: Submit the following:
   1. Product information for components specified herein.
   2. List of equipment (wire, cable, devices, enclosures, and raceways) and the corresponding text for the label.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Engraved, plastic laminated nameplates, signs, and instruction plates. Engrave stock melamine plastic laminate 1/16 inch minimum thickness for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Use white letters for engraved nameplates and punch for mechanical fasteners.

2.2 WIRE AND CABLE LABELS

A. General
   1. Self-laminating adhesive laser labels.
   2. Machine printable with a laser printer.
   3. Cable size: 0.16 – 0.32” OD
   4. Color: white with black lettering

B. Manufacturer, or equal:
   1. Brady #WML–211-295 and #WML-311-292 wire marking labels

2.3 DEVICE LABELS

A. Self-laminating, type on tape, adhesive labels. Use Helvetica 12 pt text

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Requirements
   1. Label the security system components. The components include, but are not limited to, the following:
      a. Equipment Enclosures
      b. Conduits
      c. Security Devices
      d. Batteries
      e. Wires and Cables
      f. Equipment Racks
      g. Terminal Blocks
      h. Relays
      i. Patch panels, and the termination positions within the patch panels.
   2. Labels shall coincide with device IDs used on the record drawings.
   3. Degrease and clean surfaces to receive nameplates and labels.
   4. Install nameplates parallel to equipment lines. Secure nameplates to equipment fronts using machine screws.

B. Equipment Cabinets
   1. Label SEC enclosures associated with the security system with a nameplate.
   2. Mount label on exterior of door, centered horizontally, and positioned one-third of the door height vertically from the top.
   3. Example: Line 1 [1/2 inch high letters]: “SEC-01”
      Line 2 [1/4 inch high letters]: “Security Equipment Cabinet”

C. Conduits
   1. Write the destination for every conduit entering a junction box, SEC, and CEC enclosure, or wireway using a black permanent ink marker next to the conduit inside the box.
   2. Example: “To SEC-01”

D. Security Devices
   1. Label devices associated with the security system with a permanent machine generated, laminated, label. Use 12 point Helvetica text with a clear background. Use white or black lettering depending upon the color of the device.
   2. Label each device in a concealed location with the system point number and address.

E. Batteries
   1. Label power supply batteries with the month and year they were installed.
   2. Example:“April 2016”

F. Wire and Cable
   1. Identify wire and cable clearly with permanent machine-generated labels wrapped about the full circumference within 1 inch of each connection.
   2. Indicate the cable ID designated on the associated field or shop drawings or run sheet, as applies.

3. Assign wire or cable designations consistently throughout a given system; i.e., each wire or cable to carry the same labeled designation over its entire run, regardless of intermediate terminations.
4. Provide labels where wire and cable first enter and exit from conduit, junction or distribution boxes; locate labels within 6 inches of the point of exit.
5. Positional labels so they are clearly visible without the need to remove wire management or other obstructions.
6. Label cables at both ends of a run and within pull and junction boxes using machine generated wrap-around labels.

3.2 CABLE LABEL FORMAT

A. Text: Helvetica font, 12 point (minimum size, unless otherwise specifically stated)

B. From Panel to Field Device
1. Line 1: Device Type and Device Number
2. Line 2: Panel ID – Port Number
3. Example:CR 001
PANEL 2 – CR5
4. Standard Device Types
a. CR = Card Reader
b. K = Camera
c. ET = Entry Telephone
d. R = Relay Output
e. A = Alarm Point
5. Standard Port Numbers
a. CR = Reader
b. M = Monitored Input
c. R = Relay Output

C. From Door Junction Box to Card Reader
1. Line 1: Device Type and Device Number
2. Line 2: Panel ID – Port Number
3. Example:CR 001
PANEL 4 – CR3

D. Miscellaneous Examples:
1. From Door Junction Box to Door Contact
a. CR001
b. DC
2. From Door Junction Box to Rex Alarm
a. CR001
b. REX ALM
3. From Panel to Rex
a. CR001
b. REX PWR
c. 12 VDC
4. From Panel to Lock
a. CR001
b. LCK PWR
c. 24 VDC

E. Communications Cable
   1. Line 1: Communication Type and Direction
   2. Line 2: Panel ID
   3. Example:RS-485 TO
      PANEL 2
   4. Typical Communication Types
      a. RS-485
      b. RS-232
      c. RS-422

END OF SECTION 28 05 53

SECTION 28 08 00

SECURITY SYSTEM ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. General: Furnish engineering, labor, materials, apparatus, tools, equipment, and transportation required to test a completed security system installation as described in these and the related Specifications.

B. Base Bid Work
   1. Comprehensive testing for all systems installed as part of the project in two distinct phases which includes:
      a. Functional Testing
      b. Acceptance Testing
   2. Produce and submit for review and approval the test results documentation for each of the two distinct phases of testing.

C. Related Sections:
   1. Section 280000, “Basic Security Requirements”
   2. Section 280513, “Security System Cabling”
   3. Section 280553, “Security System Labeling”
   4. Section 280800, “Security System Acceptance Testing”
   5. Section 281300, “Access Control and Alarm Monitoring System”
   6. Section 282300, “Video Surveillance System”

1.2 SUMMARY OF ACCEPTANCE TESTING ACTIVITIES

A. Overview
   1. The purpose of these testing activities is to ensure the security system operates properly and per the Owner’s requirements. Security systems are very complex from both an equipment and programming standpoint and thorough testing is necessary to ensure correct operation.
   2. Perform testing activities after-hours or on weekends when the system is not being actively utilized and the building is generally unoccupied. This will minimize the amount of irrelevant activity in the system activity reports that will be used as a record of the Functional Testing and Acceptance Testing test results documentation.

B. Functional Testing
   1. Functional Testing represents a complete and documented test of the security systems. At a minimum, Functional Testing shall demonstrate proper operation of security system components, including: devices, sensors, switches, power supplies, controllers, input/output boards, relays, network communications, tamper switches, initiating circuits, and associated accessories and appurtenances required for system functionality.
   2. Perform Functional Testing of security systems to verify correct operation prior to scheduling the Acceptance Testing.
   3. Document the results of the Functional Testing and submit to the Engineer along with system activity reports for approval.

4. Functional Testing test results documentation shall be reviewed and approved prior to scheduling the Acceptance Testing.

C. Acceptance Testing
   1. Acceptance Testing represents a final walk test with the Engineer and Owner to demonstrate proper operation of security system components including system integration, programming, operational capabilities, and functional performance.
   2. Perform Acceptance Testing of the security systems in the presence of the Engineer and Owner to demonstrate fully functional and completely operational security systems.
   3. Submit Acceptance Testing test results documentation and punch list/deficiencies corrections, prior to Owner approval of Substantial Completion and the start of the Warranty period.

1.3 SUBMITTALS

A. Functional Testing test results documentation submittal

B. Acceptance Testing test results documentation submittal

C. Operation and Maintenance (O&M) Manuals: Submit O&M Manuals for review and approval at the completion of the project consisting of the following:
   1. Warranty letter: copy of Warranty letter reflecting start and end dates, and instructions covering warranty procedures.
   2. Functional Design Manual: includes a detailed explanation of the operation of the system.
   3. Hardware Manual, which includes:
      a. Pictorial parts list and part numbers
      b. Pictorial and schematic drawings of wiring systems including devices, control panels, instrumentation, and annunciators
      c. Telephone numbers for the authorized parts and service distributors
      d. Service bulletins
   4. Software Manual, which includes:
      a. Use of system and applications software
      b. Initialization, start-up, and shut down procedures
      c. Alarm reports
   5. Operator’s Manual, which fully explains procedures and instructions for the operation of the system and includes:
      a. Computers and peripherals
      b. System start up and shut down procedures
      c. Use of system, command, and applications software
      d. Recovery and restart procedures
      e. Graphic alarm presentation
      f. Use of report generator and generation of reports
      g. Data entry operator commands
      h. Alarm messages and reprinting formats
      i. System access requirements
      j. Service maintenance call procedures
   6. Maintenance Manual, which includes:
      a. Instructions for routine maintenance listed for each component, and a multi-page summary of component’s routine maintenance requirements
      b. Detailed instructions for repair of the security system
      c. A summary of the software licenses, including license numbers, quantity of clients, summary of the software options provided, and database capabilities

d. A list of IP addresses used and with which system component they are associated, including MAC address
e. A list of gateway addresses, subnet masks, DNS servers, and host name information

7. Test Results Manual which includes the document results of tests, required under this Specification, organized by System, Floor, and Door.
8. As-Built Drawings, which includes 11”x17” prints of the as-built drawings.

D. As-Built Drawings
1. Submit As-Built Drawings for review and approval at the completion of the project.
2. As-Built Drawings shall fully and accurately represent installed systems and conditions, including: actual locations of devices and components, actual cable and terminal block numbering, and actual wire routing and wiring (wire type, gauge/size, rating, etc).
3. Record changes in the work during the course of construction on blue or black line prints. Transfer construction mark-ups to AutoCAD or Revit format drawings at the completion of the project.
4. Include the following additional information:
a. Device addresses and IP address information
b. Settings for each camera (lens specs, mm setting, auto shutter setting, and other available camera settings, etc.)
5. Include approved Shop Drawings.
6. Final acceptance requires the Engineer’s approval of the As-Built Drawings.

E. Owner’s acceptance, Substantial Completion, and start of the Warranty period requires all submittals above be approved and punch list deficiencies be corrected.

1.4 QUALITY ASSURANCE

A. Provide a project manager to coordinate the security system acceptance testing work with other trades.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 SCHEDULING

A. Coordinate the security system Functional Testing and Acceptance Testing acceptance testing specific activities into the overall project construction schedule.

B. Provide the Engineer and Owner with a minimum one week notice prior to scheduling Functional Testing and Acceptance Testing activities.

3.2 TESTING REQUIREMENTS

A. Site Tests

1. At a minimum, security system testing requirements shall include the following tests (where applicable to the project):

a.	Building Perimeter Test:	Test doors, cameras, and devices related to securing the perimeter of the building.
b.	MDF/IDF Test:	Test devices related to securing the MDF and IDFs . Inspect system panels, power supplies, and other related security equipment located in these areas.
c.	Access Control System Test:	Test the software for correct programming and setup. Verify correct integration with the Intrusion Detection System and Video Surveillance System.
d.	Video Surveillance System Test:	Test the system for correct programming, operation, and alarm camera call-up.
e.	Video Recording System Test:	Test the recording system for correct programming, alarm recording, and event retrieval. Verify correct integration with the ACAMS and IDS system for alarm call-up. Test and verify the system is viewable from client workstations.
f.	Video Camera Test:	Review cameras for proper coverage, quality of video, focus, configuration, etc.
g.	Other Readers/Door Test:	Test remaining card readers and doors not included in the above tests.
h.	Battery and UPS Load Test:	Disconnect AC power to security system equipment to verify battery operation functions and system remains fully operational.
i.	Door Hardware Test:	Coordinate with the Division 08 door hardware contractor to resolve electrified locking door hardware failures and door alignment or door closer problems.

B. Site Tests Preparation

1. Provide device identification numbers that differ from or were not included on the original Construction Drawings.
2. Provide a complete systems point list.
3. Provide paper and toner for the printer so that an event log can be printed out and attached to the test reports as verification of test sequence and systems response.
4. During testing, provide technicians familiar with the installation to assist with the test. Stage the technicians as follows: one at the host, one at the device being tested, and one runner responsible to furnishing tools, step ladders, etc.
5. Provide radios for use by the Engineer and Owner during testing.
6. Provide pre-programmed access cards for use during testing. Provide one authorized card for each access level. Provide one card with no access authorization. Provide keys for lockset mechanical key override.

3.3 TEST PROCEDURES

A. Follow manufacturer’s written test procedures for each type of device and system.

3.4 FIELD DOCUMENTATION

A. Provide printed system documentation containing detailed wiring diagrams for each security equipment enclosure. Documentation shall include, at a minimum, layout of equipment, elevation detail, complete parts list, and complete wiring diagrams for each security system controller, input / output board, relay, and power supply.

B. Provide a printed service log for each security equipment enclosure. Service log shall include, at a minimum, columns for the following information: date of service, description of work performed, service technician(s), and service company.

C. Neatly fold the printed system documentation and service log and place it inside a clear plastic pocket affixed to the inside door of the security equipment enclosure.

3.5 TRAINING

A. Upon completion of the Acceptance Testing, provide training to the Owner's representatives, at times convenient to them, in the function and operation as well as the service and maintenance of the security systems.

B. Utilize the production database for the training to give the users project-specific examples from which to learn.

C. Provide 16 hours, minimum, of on-site training by a factory trained representative. Maintain a sign-in sheet with names and dates of persons trained and forward to Owner upon completion of training.

D. Provide for designated Owner’s representatives to attend off-site factory certification training for all systems installed as part of the project, including:
   1. Access Control and Alarm Monitoring System
   2. Video Surveillance System
   3. Intrusion Detection System
   4. Security Communications System

END OF SECTION 28 08 00

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 28 13 00

ACCESS CONTROL AND ALARM MONITORING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes
1. ACAMS, including access control units, input/output units, and card readers
2. ACAMS power supplies
3. Alarm initiating devices, including: magnetic switch contacts, request-to-exit sensors,
4. Power supplies
5. Local audible alarms/sounders
6. Security operations center fixtures and furnishings
7. Interface to electric door hardware, ADA door operators, and gate operators
8. Interface to Fire/Life-Safety system
9. Interface to VSS and other security subsystems with bi-directional communication

B. Products Furnished but not Installed under This Section
1. None

C. Products Installed but not Furnished under This Section
1. New electric feed-through power transfer hinges
2. Electrified locking hardware cable and termination to transfer hinge and security system

D. Products Specified but not Installed under This Section
1. Access control devices inside elevator cabs, including card readers, interface relays, and reader modules.

E. Products Furnished and Installed under Another Section
1. 120VAC power
2. Telecommunication pathways; refer to Section 270528 and/or 270532.
3. Network switches, with Power over Ethernet (PoE)

F. Related Sections
1. Consult other Divisions, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a fully functional and completely operational system.
2. Section 087100, “Door Hardware”
3. Section 280000, “Basic Security Requirements”
4. Section 280513, “Security System Cabling”
5. Section 280553, “Security System Labeling”
6. Section 280800, “Security System Acceptance Testing”
7. Section 282300, “Video Surveillance System”
8. Section 283100, “Fire Detection and Alarm”

1.2 REFERENCES

A. Comply with the References requirements of Section 280000.

B. In addition to the codes and standards listed in Section 280000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 497, “Protectors for Paired-Conductor Communication Circuits”

1.3 DEFINITIONS

A. Definitions as described in Section 280000 shall apply to this Section.

B. In addition to those definitions in Section 280000, the following list of terms as used in this specification defined as follows:
   1. “A” and “AMP”: amperes
   2. “ACAMS”: access control and alarm monitoring
   3. “IDS”: intrusion detection system
   4. “LAN”: Local Area Network
   5. “NC”: Normally closed
   6. “NO”: Normally open
   7. “REX”: request to exit
   8. “SCS”: security communications system
   9. “UPS”: uninterruptable power supply
   10. “VAC”: volts alternating current
   11. “VDC”: volts direct current
   12. “VMS”: video management system
   13. “VSS”: video surveillance system

1.4 SYSTEM DESCRIPTION

A. General: Provide engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working Access Control and Alarm Monitoring system installation, as described in these specifications.

B. Access Control and Alarm Monitoring System (ACAMS) Overview
   1. The ACAMS is utilized for electronically controlling access within the building for employees, visitors, delivery personnel, and persons.
   2. ACAMS consists of an ACAMS server card readers and alarm initiating devices (refer to the drawings for locations of field panels, card readers, and other devices). The server will communicate with the control panels via the Owner’s LAN and/or hardwire connections. The control panels control the electronic door hardware allowing or disallowing passage through a controlled door or gate.

C. ACAMS Server and Software
   1. Server (to host ACAMS software): Utilize the existing server to host ACAMS software package.

D. Card Readers / Door Devices
   1. Provide wireless proximity card readers, including rough-in, wiring, reader, and other components for a complete system and connect to the ACAMS.
   2. Provide door contacts and request-to-exit motion detectors for card reader controlled doors and connect to the ACAMS. Refer to drawings for configurations and instances.

3. Provide integrated door contacts for non-card reader controlled doors noted on drawings (such as ground floor perimeter doors) and connect to the ACAMS. ACAMS shall monitor these doors. Program the ACAMS to alarm should the monitored doors open when not authorized.

E. Provide end of line resistors as required (e.g., on supervised lines).

F. Provide interface to ADA automatic/power assist door operator and corresponding actuator push plates

G. Fire/Life-Safety System Interface
1. Coordinate with Fire/Life-Safety system contractor to automatically drop power from stairwell, elevator vestibule lobby, and other doors within the path of egress upon alarm activation of the Fire/Life-Safety system.
2. Coordinate with Fire/Life-Safety system contractor for scheduled release of electromagnetic door holders on designated card reader doors or scheduled unlocked doors as indicated on project drawings. Provide ACAMS output modules as necessary to interface with Fire/Life-Safety system to release electromagnetic door holders on doors that are required to close and lock on scheduled events.

H. Extra Materials
1. Furnish 10% spare parts of total installed the following (round up to the next complete device):
   a. Card readers
   b. Relays
2. Fuses: 5 of each type of fuse

1.5 SUBMITTALS

A. Quantity: Furnish quantities of each submittal as noted in Section 280000.

B. Contractor Qualifications: Submit certification letters for the manufacturer of the ACAMS.

C. Product Data: Submit product information for components specified herein.

D. Shop Drawings: Include the following, minimum:
1. Device placement on floor plans and RCPs
2. Point-to-Point Diagrams: Include wiring, points of connection and interconnecting devices between the following:
   a. ACAMS control panel
   b. ACAMS card reader
   c. ACAMS power supplies
   d. Card Readers
   e. Door and lock position monitoring contact switches and request-to-exit sensors
   f. Interface to electrified door hardware
   g. Interface to Fire/Life-Safety system
   h. Cable conductors (identify conductors on the point to point diagrams with the same tag as the installed conductor)
   i. Miscellaneous control relays
3. Block Diagram/Riser Diagram: Show ACAMS components, conduit, wire types, and sizes between them, including cabling interties between termination hardware.
4. Schedules: Include schedules for ACAMS control panels that show each point ID with a description of the connected devices

5. Include user interface graphics with icons and control buttons displayed.
6. Include custom mounting details.

E. Submittal Description: Training Submittal
1. Format: PDF
2. Contents:
a. Cover sheet, showing:
1) Owner Name
2) Project Name and Address
3) Project Submittal Number
4) Submittal Name
5) System Name
6) Specification Section Number (e.g., “Section 281300”)
7) Date of Submittal. Format: Month Day, Year (e.g., “January 1, 2016”)
8) Contractor Name
b. Table of Contents
c. Training Schedule
d. Training Course outline/ agenda
e. Course materials and training manuals for the following users as applicable:
1) System Administrator
2) Security staff
3) Operator, and nurse/staff.

F. Submittal Requirements at Closeout:
1. As-Built Drawings: submit as-built drawings that includes approved block diagram, riser diagram, wiring diagram, security control room layout and elevations, floor plans, and reflected ceiling plans, and site plans showing device locations.
2. O&M Manual: submit O&M Manual as a binder or soft copy (bookmarked PDF) including the following, at a minimum:
a. Product data – approved submittals (‘cleaned up’) and electronic
b. As-built drawings, printed to 11x17 / tabloid landscape and electronic PDF files and native files (DWG or RVT) on storage media
c. Warranty statement and service protocol (guidelines, contact numbers, etc.)
d. Maintenance requirements
e. Station Matrix, printed to 11x17 / tabloid landscape and electronic PDF files and native XLSX file on storage media
f. Include information for the network switches and ports.

1.6 WARRANTY

A. Warrant work and the system to perform as described within this Section for a period of one year from the date of system acceptance. The warranty shall cover system operation/performance, parts, and labor. During the warranty period, respond within 4 hours and correct deficiencies within 24 hours of notification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Access Control and Alarm Monitoring System
1. Secureall to match client’s standards

B. Card Readers
   1. Secureall to match client's standards

2.2 CARD READERS

A. Description / Features:
   1. FCC and CE certified, and conform to the following ISO standards:
      a. 15693 (CSN read-only)
      b. 14443A (CSN read-only)
      c. 14443B (CSN read-only)
   2. Capable of reading the following frequencies and card formats:
      a. 125 kHz and 13.56 MHz
   3. Utilize a Wiegand protocol for communication for compatibility with standard access control systems.
   4. Multi-color LED and an audible sounder to indicate the status of the door
   5. For exterior locations, reader shall be fully weatherized with a rugged, polycarbonate enclosure, designed to withstand an operating temperatures of -22 to 150 degrees Fahrenheit (-30 to 65 degrees Celsius) and operating humidity of 5-95% non-condensing.

B. Functions:
   1. Card reader shall continuous emit radio radiation with a continuous sensing of an access card.
   2. Upon reading an access cord, the card reader shall initiate a single transmission to the ACAMS controller.
   3. Upon receiving status from the ACAMS controller, the card reader shall change the state of the LED to the programmed state.

C. Manufacturer:
   a. SecuerAll #SA-CDR
   b. SecuerAll #SA-CCR
   c. SecuerAll #SA-GSW
   d. SecuerAll #SA-MDR
   e. SecuerAll #SA-PWR
   f. SecureAll #SA-ROU
   g. SecuerAll #SA-PHR

2.3 MAGNETIC CONTACT SWITCHES

A. Magnetic contact switches shall be UL 634 Listed.

B. Wood, Steel, and Hollow Metal Doors
   1. Description / Features
      a. Mounting: Recessed
      b. Switch Type: Double Pole, Double Throw
      c. Gap Distance: 0.5" maximum
   2. Manufacturer, or equal:
      a. Magnasphere #MSS-19CL; 3/4" dia., open loop contact switch, with leads
      b. Magnasphere #HSS-L2C; UL 264 Level 2 high security recessed contact switch, with leads

2.4 REQUEST-TO-EXIT SENSORS

A. General
1. Power: 12 or 24VDC, 35mA
2. Relay Output: 2 form “C” contacts
3. Adjustable relay latch time
4. Programmable retrigger or non-retrigger mode
5. Radio Frequency Interference (RFI) Immunity range from 26 to 1,000 MHz at 50 v/m

B. Manufacturer, or equal:
1. Bosch #DS160 with TP160 trim plate
2. Honeywell #IS320WH with IS310WHTP trim plate
3. Interlogix #RCR-REX motion sensor REX

2.5 INTERFACE RELAYS

A. Refer to section 280000 for relay product requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
1. Install equipment per manufacturer’s instructions.
2. Install devices, stations, etc., square and plumb. Set flush-mounted units so that the face of the cover, bezel, or escutcheon matches the surrounding finished surface.
3. Install so that there are no gaps, cracks, or obvious lines between the trim and the adjacent finished surface.
4. Install to heights shown on drawings. Heights shall comply with applicable ADA requirements.
5. Provide supervisory and end of line resistors as required.

B. Card Readers
1. Install card reader to the rough-in, not directly to dry wall.
2. Connect readers directly to reader boards. Do not daisy chain readers together.
3. Wire the card reader‘s multi-color LED to indicate the following status of the door.
a. Red = the door is secure (locked).
b. Green = the door is unsecured (unlocked).
c. Yellow = the card reader is not functioning (off-line/trouble), is processing a read request, or has denied access.
4. Wire/program the card reader to produce an audible beep tone to indicate to the user:
a. The card was read and/or access was denied.
b. Door is being held open and needs to be closed.
5. Enable optical tamper using configuration card. Wire the card reader’s optical tamper to spare input on the ACAMS reader module and jumper ground wire from door contact to provide a normally closed circuit.

C. Door Hardware
1. Setup and conduct a door hardware coordination meeting.
2. Coordinate the installation and termination of the security cable with the installation of the electric door hardware and transfer hinge.

3. Route power to electrically controlled locks on Life-Safety doors through fire alarm output to automatically unlock the door upon activation of Fire/Life-Safety system. Connect fire alarm output to the disconnect relay on the associated 24VDC lock power supply.
4. Provide cable and terminate wires to delayed egress devices for monitoring activation of delayed egress by the ACAMS system.

D. Door Contacts
1. Install 6” from latch side of door.

E. Request-To Exit Motion Detectors
1. Install motion detector on the secured (protected) side of door. Install so that its detection pattern is not obstructed by exit signs, light fixtures or other objects that would interfere with proper operation.
2. Adjust relay hold time and pattern to properly detect valid exit and allow shunting of door contact.
3. Adjust detection sensitivity to pulse.
4. Mask detector lens to provide a confined detection area limited to the door handle or push bar.
5. Run wire inside structural tube steel frame into back of conduit body for cage locations.

3.2 PROGRAMMING

A. Prior to the completion of construction, schedule a meeting with the Owner to determine the programming criteria. Document the results of the meeting and perform necessary programming to achieve the Owner’s requests. During the meeting, discuss the following:
1. Access card levels and door groupings
2. Alarm priority levels
3. Schedules and time codes
4. Holidays and holiday types (priorities)
5. Action/responses from individual input points
6. Standard and custom (expanded) reports
7. Defining alarm messages and standard response messages applicable to site
8. Routing of alarm points to selected pagers
9. Routing of alarm points to operator’s workstations, printers, and history files
10. Owner’s graphics – develop sample graphic complete with icons and text. Alarms to appear on building floor plans depicting the nature and location of alarms. Review and revise graphic layout as required by Owner.
11. System database backup procedures
12. Video integration camera call-up

B. Program and setup the system such that no additional programming other than entering new access cards is required. Include setup of available features of the software.

C. Import Owner’s cardholder database.

D. Using CAD drawing files of floor plans, perform the following relative to system graphics:
1. Delete non-applicable drawing layers and details to arrive at simple floor plans of the building as built.
2. Convert drawings to a graphic file format compatible with the Owner’s access control and alarm monitoring system.
3. Load drawing files into the system.
4. Apply new and predefined icons and other points on each graphic to indicate point and control status.

5. Link graphic images/icons to represent reader, monitor, alarm initiating devices, and control points.
6. Program device icons on plans with functionality.
7. Create camera call-up events.
8. The point names shown on the as-built drawings shall match the system point schedule.

E. Program ACAMS such that alarm events generate email notification to offsite addresses via the Internet. Also, as required by the Owner, program ACAMS such that alarm events generate pages.

F. Program customized client workstation log-ins (restrict functions by user privileges).

G. Program routing of monitor and control points. Route activations and restore messages to one or more of the following locations as directed by the Owner's Representative:
1. One or more system workstations
2. One or more system printers
3. One or more alphanumeric pagers
4. History files in addition to the above
5. History files only

H. Program the system such that reliance on a remote host for routine building operations, such as scheduled door commands and conditional events, are minimized to the greatest extent possible and decisions are made at the local building controller.

I. System Operation, Alarm and Reporting Function: Program door control panel tamper switches to immediately report as a separate "tamper" point to the system resulting in an alarm condition displayed in both text and graphic form on the applicable workstation(s) and an alarm message transmitted to the appropriate pager(s).

J. Program the system in a manner that minimizes the amount of time required for the users to make updates and maintain the system on a daily basis especially updates that impact card holder record updates. Nested programs, such as reader groupings used in access codes, shall be used to the greatest extent possible such that single actions are required to update an entire card data population. If there is a question regarding the appropriate approach to programming, given the flexibility of most systems, contact the Engineer prior to any initial programming

K. Perform 2 full system back-ups at completion of initial programming and deliver one copy to owner with letter of Transmittal explaining information included in back-up and brief description of recovery procedures. Label the second removable storage device and store onsite. Perform back-ups on a regular bases through the remainder of the project.

L. Customize menus with the assistance of the factory to "gray-out" features not used on project (such as elevator control).

M. Perform field software changes after the initial programming session to "fine tune" operating parameters and sequence of operations based on revised operating requirements.

N. Password management – refer to Section 280000.

3.3 EXTRA MATERIALS

A. Furnish extra materials to Owner. Produce a transmittal with an itemized list including quantities, recipient, and receipt date. Submit copy of Owner-signed transmittal with project closeout documents.

B. Place fuses inside each equipment/panel and power supply enclosure.

C. Turn over keys (equipment enclosures, low voltage power supplies, security junction boxes, rack cabinets, etc.) to the Owner. Produce a transmittal with an itemized list of keys, recipient, and receipt date. Submit copy of Owner-signed transmittal with project closeout documents.

3.4 TRAINING

A. Combine training on the ACAMS with training on the VSS (Section 282300).

B. Training Requirements
   1. Security Staff/System Operators:
      a. Prior to the first day of business at the new facility, provide 1 day of training, 4 hours per day.
      b. Two months later, provide 1 day of training, 4 hours per day.

3.5 TESTING

A. Test ACAMS in accordance with Section 280800.

END OF SECTION 28 13 00

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 28 23 00

VIDEO SURVEILLANCE SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes
1. Video Surveillance System (complete system)
2. Video Management System (software)
3. Network Video Recorder and Storage (hardware)
4. Fixed cameras, lenses, mounts, and housings
5. Pan-Tilt-Zoom (PTZ) cameras, lenses, mounts, and housings
6. Panoramic cameras, lenses, mounts, and housings
7. Power Supplies
8. Network switches, with Power over Ethernet (PoE)

B. Products Furnished But Not Installed Under This Section
1. None

C. Products Installed But Not Furnished Under This Section
1. None

D. Products Specified But Not Installed Under This Section
1. None

E. Products Furnished And Installed Under Another Section
1. 120VAC power
2. Telecommunication cabling between telecom room and cameras; refer to Section 271513.
3. Network switches, with Power over Ethernet (PoE)

F. Related Sections
1. Consult other Divisions, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable system.
2. Section 271513, “Communications Horizontal Cabling”
3. Section 280000, “Basic Security Requirements”
4. Section 280800, “Security System Acceptance Testing”
5. Section 280513, “Security System Cabling”
6. Section 280553, “Security System Labeling”
7. Section 281300, “Access Control and Alarm Monitoring System”
8. Section 281600, “Intrusion Detection System”
9. Section 282600, “Security Communications System”

1.2 REFERENCES

A. Comply with the References requirements of Section 280000.

B. In addition to the codes and standards listed in Section 280000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 497, “Protectors for Paired-Conductor Communication Circuits”

1.3 DEFINITIONS

A. Definitions as described in Section 280000 shall apply to this Section.

B. In addition to those definitions in Section 280000, the following list of terms as used in this specification defined as follows:
   1. “A” and “AMP”: amperes
   2. “ACAMS”: access control and alarm monitoring
   3. “CCD”: charge-coupled device
   4. “CMOS”: complementary metal oxide semiconductor
   5. “DSP”: digital signal processing
   6. “FC”: foot candles
   7. “FPS”: frames per second
   8. “IDS”: intrusion detection system
   9. “KVM”: keyboard, video, mouse switch
   10. “NAS”: network-attached storage
   11. “NVR”: network video recorder
   12. “PoE”: Power over Ethernet
   13. “PTZ”: pan-tilt-zoom
   14. “RAID”: redundant array of independent disks
   15. “SAN”: storage area network
   16. “VAC”: volts alternating current
   17. “VDC”: volts direct current
   18. “VMS”: video management system
   19. “VSS”: video surveillance system

1.4 SYSTEM DESCRIPTION

A. General: Provide engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction, and special or occasional services as required to make a complete working video surveillance system, as described in this specification.

B. Video Surveillance System (VSS) Overview
   1. The VSS is an enterprise-wide system generally comprised of fixed cameras (with associated mounting apparatus, housings, cabling, etc.), video management system (software), and network video recorder and storage (hardware), that provides live video feeds for real-time surveillance and monitoring, recorded video for forensic analysis.
   2. The VSS serves as the video component of the facility’s overall security and safety program. Camera deployment and their respective field-of-views are strategically determined to coincide with points of security and access control as well as surveillance of open and high-security spaces.
   3. The VSS interconnects and integrates with the ACAMS, IDS, and security/emergency communications system such that alarms/events generated within the other systems (generally carried through the ACAMS) cause VSS and the VMS to behave in a programmed manner.

a. Program active icons in graphic user interface map in the ACAMS to allow camera call up based on the selection of icon.

C. Video Surveillance System (VSS) Scope
1. Server (to host VMS software): Provide one server to host VMS software package.
2. Video Storage hardware / Network Video Recorder (NVR): Provide one server to store video.
3. Video Management System Software: Provide VMS software package, including loading the VMS package onto the VMS server and integrating the software onto the network and integrating the video storage hardware into the VMS. Coordinate with the Owner's IT department for network integration and other IP-related requirements. Provide VMS licenses in a quantity sufficient to support the project's cameras and client workstations plus 20% (minimum, round up to nearest whole number).
4. Program the software system to meet the project requirements including programming recording input points, video call up, and other aspects of the system. Provide software interface to the ACAMS, IDS, and security/emergency communications system for alarm call up of cameras on predefined alarm events.
5. VMS Client Software: Provide (load and configure) VMS client software onto security workstation(s) (provided under Section 281300) for monitoring and viewing capabilities as shown on the drawings.
6. Provide cameras as shown on the drawings. Provide outdoor housing and mounts for exterior cameras.
7. Provide power supplies to supply power to cameras. Do not combine with ACAMS power supplies.

D. Tamper Monitoring: Provide one tamper switch within each PTZ dome enclosure to monitor the enclosure, including wiring, connection to ACAMS panel; and programming this tamper switch into ACAMS system as monitor input point.

E. Surge Protection: Regardless of who provides the cabling to outdoor cameras, ensure that the connection infrastructure for outdoor cameras receive proper protection against transient voltages. Installations shall comply with NEC 800.47, NEC 800.50 and NEC 800.90.

F. Extra Materials
1. Furnish 10% spare parts of total installed the following (round up to the next complete device):
a. Fixed cameras

1.5 SUBMITTALS

A. Contractor Qualifications: Submit certifications for the manufacturers of the video surveillance equipment.

B. Product Data: Submit product information for components specified herein.

C. Shop Drawings:
1. Device placement on floor plans.
2. Point-to-Point Diagrams: Include wiring, points of connection and interconnecting devices between the following:
a. Video surveillance system, monitors, and recording equipment
b. Network Switches
c. Devices connected to the system
d. Miscellaneous control relays

e. Conductors (identify conductors on the point-to-point diagrams with the same tag as the installed conductor)

3. Camera Matrix: Submit as an Excel-compatible spreadsheet a matrix that includes each camera. The matrix, using the same ID as shown on the as-built drawings, shall include the following column headers, at a minimum:
   a. Device
   b. Device Identifier
   c. Location
   d. MAC Address
   e. IP Address
   f. IDF Room
   g. Network Switch
   h. Switch Port
4. Block Diagram/Riser Diagram: Show the video surveillance system components, conduit, wire types, and sizes between them, including cabling interties between termination hardware.
5. User interface graphics with icons and control buttons displayed.
6. Custom mounting details

D. Submittal Requirements at Closeout:
   1. As-Built Drawings (this may be combined with the ACAMS as-built drawings): submit as-built drawings that includes block diagram, riser diagram, wiring diagram, and reflected ceiling plans, and floor plans and site plans showing camera locations (tagged with a unique ID per camera), security console (with video monitors).
   2. Camera Matrix: submit as an Excel-compatible spreadsheet a matrix that includes each camera. The matrix, using the same ID as shown on the as-built drawings, shall include the following column headers, at a minimum:
      a. Camera Type
      b. Camera ID (shall match the as-built plans)
      c. Camera manufacturer and model (shall match the approved product data submittal)
      d. Camera lens manufacturer and model (shall match the approved product data submittal)
      e. Location
      f. MAC Address
      g. IP Address
      h. IDF Room
      i. Network Switch
      j. Switch Port
      k. Maintenance requirements
   3. O&M Manuals: submit O&M Manual as a binder or soft copy (bookmarked PDF) including the following, at a minimum:
      a. Product data – approved submittals (‘cleaned up’) and electronic
      b. As-built drawings, printed to 11x17 / tabloid landscape and electronic PDF files and native files (DWG or RVT) on storage media
      c. Warranty statement and service protocol (guidelines, contact numbers, etc.)
      d. Maintenance requirements
      e. Station Matrix, printed to 11x17 / tabloid landscape and electronic PDF files and native XLSX file on storage media
      f. Network switches and ports configuration information

1.6 WARRANTY

A. Warrant the system for a period of one year from the date of system acceptance. The warranty shall cover system operation/performance, parts, and labor. Correct deficiencies within 24 hours of notification.

PART 2 - PRODUCTS

2.1 NETWORK VIDEO RECORDER

A. Features
1. Complete network video platform that encompasses video recording, video viewing, reviewing recorded video, and storing video for indefinite periods of time.
2. Full control of camera selections, sequencing, and viewing modes
3. The system simultaneously records, displays live video, and plays back video. None of the video operations interfere with each other. Live view and video playback does not interrupt the recording process.
4. Recorders capture, digitize, and store video. Recorders may record full-time, in response to an alarm, or based on a user-defined schedule. Full-time recording refers to 24 hours per day, 7 days per week, 365 days per year.
5. Network: Internal network interface for connection to a 10/100BaseT LAN using TCP/IP network protocol
6. Web Access: Web-based remote access via browser

B. Recorders
1. Video Information
   a. Store for each clip video source, capture date, start time, and stop time. Source identified as either a monitor or a camera. Information to be available during playback
   b. Store alarm information in the database on the main server when the video is in response to an alarm condition.
2. Video Storage
   a. Video stored in clips on the recorder's internal hard drive. As the hard drive becomes full, groom oldest clips to make room for new video.
   b. Ability to utilize a variety of network storage devices such as external disk arrays, RAID and NAS/SAN devices, and external disk drives for exporting, backup, or sharing images.
3. Video Authentication
   a. Fingerprint each video clip through a mathematical algorithm during the video capture process. The fingerprint becomes part of the clip and used by the playback software to verify the video has not been altered.
4. Alarm Recording
   a. Recording Options
      1) Alarm condition via activation of an external alarm contact.
      2) Internal video motion detection
   b. Recording programmable by camera and by time and date schedule.
   c. Allow a mix and match of continuous recording and alarm recording, based on camera input and capture card connection.
   d. Pre and post alarm recording
5. Video Motion Detection
   a. Each video input capable of detecting activity from camera input and to initiate an alarm condition.

b. Video motion detection areas operator selectable for each camera input. If the scene changes within the alarm area, an alarm condition is initiated.
6. Viewing of both live and archived images, from multiple remote systems.
7. Remote event notification
8. Password protected via user authorization, with profiles assigned by the system administrator, and database tracking of evens.

C. Manufacturer, or equal:
1. BCD Video
2. DNF Security
3. Dell

D. Software:
1. Salient

2.2 CAMERAS

A. Fixed IP Interior Dome Camera
1. Type: Color, vandal-resistant
2. Power: PoE
3. Imager: 1/3 inch format, unless otherwise noted
4. Lens Mount: Accept a “CS” mount auto or manual-iris lens
5. Resolution: 1080p HD
6. Minimum Light Level: 0.1 fc imager illumination at full video, unless otherwise noted
7. Lens: 3 to 9mm, unless otherwise noted
8. Frame Rate: 30fps at H.264
9. Manufacturer, or equal:
a. Axis #P3346-V IP dome megapixel camera
10. Accessories, or equal:
a. Axis #5502-781 ceiling mount kit
b. Axis #5502-401 mounting plate

B. Fixed IP Exterior Dome Camera
1. Type: Color, vandal-resistant
2. Power: PoE
3. Imager: 1/3 inch format, unless otherwise noted
4. Lens Mount: Accept a “CS” mount auto or manual-iris lens
5. Resolution: 1080p HD
6. Minimum Light Level: 0.1 fc imager illumination at full video, unless otherwise noted
7. Lens: 3 to 9 mm, unless otherwise noted
8. Frame Rate: 30fps at H.264
9. Manufacturer, or equal:
a. Axis #P3346-VE vandal resistant fixed dome with remote focus and zoom for outdoor use
b. Sony
10. Accessories, or equal:
a. Axis #T91A61 wall bracket
b. Sony

2.3 LINE PROTECTORS

A. For use on data cables serving exterior cameras.

B. Manufacturer, or equal:
   1. Transtector #1101-994
   2. DITEK

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION PLANNING

A. Prior to the completion of construction, schedule a meeting with the Owner and the Engineer to determine the system programming requirements, such as the following:
   1. Camera naming/numbering
   2. Field of view per camera
   3. Settings for contrast, wide dynamic range, and auto-iris
   4. Camera call-up and recording features, including video motion detection

B. Camera Locations
   1. Prior to installation, coordinate/confirm camera locations. As needed, perform a field walk with the Owner. Obtain Owner signoff of camera locations and field of view per camera prior to installation.
   2. Prior to rough-in construction, coordinate rough-in locations and requirements per camera.

3.2 INSTALLATION

A. Network Video Recorder
   1. Rack mount VSS equipment located in the data center.

B. Network Switch
   1. Rack mount network switches located in the data center.

C. Cameras
   1. Field determine exact placement of cameras to ensure complete coverage.
   2. Field determine fixed camera lens size to ensure complete coverage.
   3. For exterior cameras, provide liquidtight flexible metallic conduit from junction box to camera housing and connect from below.

3.3 PROGRAMMING

A. Network Video Recorder
   1. Connect the servers/storage to the Owner’s LAN/WAN to allow remote viewing from authorized workstations utilizing the VMS client viewing software. Configure the cameras and servers at the following initial requirements:
      a. Codec: H.264
      b. Resolution: 1080p
      c. Storage: 60 Days (minimum)
      d. Recording: Continuous
      e. Frame Rate: 30fps

B. Document the results of the meeting and perform necessary programming to achieve the Owner’s requests.

C. Setup and program the system such that no additional programming required.

D. Use the camera naming convention agreed upon at in the programming meeting when programming point names into the system.

E. Perform two full system back-ups at completion of initial programming and deliver one copy to the Owner with a letter of transmittal explaining information included in back-up and brief description of recovery procedures. Perform back-ups on a regular bases through the remainder of the project.

3.4 TESTING

A. Test the video surveillance system in accordance with Section 280800.

3.5 SYSTEM OPERATION CONFIRMATION

A. At 30 days after substantial completion, perform field review of video surveillance system software with the Owner to "fine tune" configuration settings for resolutions, recording, and frame rate to meet the storage and operational requirements.

END OF SECTION 28 23 00

SECTION 283111

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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. This Section includes the following systems for the building:

1. Fire Alarm Systems.

B. Drawings supplied with this specification shall be used as a reference for the requirement and location of system components.

C. At the time of bid, all exceptions taken to these Specifications, variances from these Specifications and all substitutions of equipment specified shall be listed in writing and forwarded to Peralta Community College District (Owner). Any such exceptions, variances, or substitutions, which were not listed at the time of bid shall not be approved or considered.

D. The Work includes all labor, materials, services, software, programming, tools, transportation, and temporary construction necessary to fabricate, install, program and test a fully operational and code compliant UL Listed and FM approved analog-addressable fire alarm system.

E. The Work includes all fees and activities required to secure approvals for necessary State and Local permits.

F. The Work includes submitting detailed Shop Drawing Plans, Wiring Diagrams, Calculations and Product Data to the Engineer and Owner for review in parallel to submitting to local officials (as required) for approval and permit as outlined in the specification and project documents.

G. The Work includes performing field quality control activities.

H. The Work includes documenting and submitting the results of integrity and functional testing.

I. The Work includes performing overall system “Pre-Acceptance” test(s) for the Engineer’s approval with the Electrician and Programmer.

J. The Work includes performing overall system “Final Acceptance” test(s) for Authority approval with the Electrician and Programmer.

K. The Work includes submitting As-built Plans and closeout documentation in DWG and PDF format to the Engineer.

L. The Work includes training Owner's personnel on the operation of the system, required maintenance tasks and frequencies, and the locations of all equipment necessary to maintain and operate the fire alarm system.

1.3 SYSTEM DESCRIPTION

A. Noncoded, addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

B. Fire alarm system.

1.4 ORDER OF PRECEDENCE

A. Should conflicts arise out of discrepancies between documents referenced in this specification, the most stringent requirement shall apply; however, should a level of stringency be indeterminable, the discrepancies shall be resolved as follows:

1. State and local codes shall take precedence over this specification.
2. The National Fire Protection Association Standards shall take precedence over this specification.
3. Drawing specific requirements as documented on the RFP drawing package.

1.5 PERFORMANCE REQUIREMENTS

A. Comply with local and national codes and RFP package documents, including:

1. California Fire Code
2. NFPA 72 – *National Fire Alarm Code*
3. NFPA 70 – *National Electric Code*
4. Contract Documents
5. Specification Documents

B. 24 VDC closed-circuit, electrically supervised, addressable, analog, automatic fire alarm system. The system shall include, but not be limited to:

1. Fire alarm control unit (FACU) and power supplies.
2. Fire Alarm Annunciator (Simplex) including a point type annunciator with a minimum of 80 zones.
3. Either System or 120 VAC Combination smoke alarms with battery back-up and carbon monoxide detectors as shown on the drawings.
4. Photoelectric, addressable analog automatic smoke detection system (in those environments suitable for proper smoke detector operation), as indicated in this section and where shown on the drawings.

    a. Immediate Vicinity of Fire Alarm Control Equipment: System type, analog, addressable, photoelectric smoke detectors with standard bases located in the immediate vicinity of all fire alarm control equipment, including remote power supplies.

b. Elevator Lobbies, Shafts, and Machine Rooms: System type, analog, addressable, photoelectric smoke detectors with standard base located in common corridors, elevator lobbies.
c. Where an area is environmentally unstable such that a smoke detector could experience high levels of dust or temperature variations above 100° F or below 32° F and the area in question is protected by an automatic sprinkler system, smoke detectors shall be omitted. If an automatic sprinkler does not protect the area, an addressable heat detector shall be installed.

5. Waterflow and Valve Supervisory Switches: Use conventional zone interface modules to monitor fire protection system alarm and supervisory functions as shown. Fire protection devices such as water flow and valve supervisory switches are furnished by the fire protection contractor. Provide necessary raceway, wiring and end of line devices to monitor.
6. Speakers and Speaker Strobes: Speakers installed to provide voice notification to all areas of the building. Standalone strobes or speaker strobes installed to provide visual notification to all common areas.

1.6 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by the Owner in parallel to submitting them to the authorities having jurisdiction.
2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.
b. NICET-certified fire-alarm technician, Level IV minimum.

B. Product Data: For each type of product indicated. Submittal shall indicate listing and approvals, selected options and electrical characteristics.

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Furnish three complete sets of as built shop drawings. The drawings shall be prepared on uniform sized sheets not less than 36 by 48 inches in size. In addition, provide a USB flash drive containing AutoCAD (Version to be coordinated with Owner) DWG and PDF format of all as built drawings and schematics.
2. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
3. Include voltage drop calculations for notification appliance circuits.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
6. Equipment List: Identify type, quantity, make and model number of each piece of equipment (including spare components) included in submittal. Types and quantities of equipment indicated shall coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

7. Shop Drawing Plans: Minimum 1/8”=1’-0” scale floor plans and corresponding riser diagram inclusive of information required by NFPA 72 requirements. Conceptual riser diagrams are not permitted.
8. Wiring Diagrams: Point-to-point fire alarm control equipment installation diagrams inclusive of information required by NFPA 72 requirements; typical wiring diagrams are not acceptable.
9. Battery Calculations: Prepared in accordance with NFPA 72 requirements and showing total standby power and total alarm power required to meet the specified system requirements. Include a complete list of current requirements during normal, supervisory, trouble, and alarm conditions for each component of the system.
10. Sequence of Operation: A sequence of operation that describes how the system responds during an alarm, supervisory and trouble condition. The description shall include fire alarm control unit LEDs, audible and visible indications; initiating devices, notification appliances, and auxiliary functions. The description shall provide sufficient information so that the exact function of each installed device and appliance is known.
11. Statement of Equipment Lifecycle: A written statement, signed by a representative of the equipment manufacturer stating that the equipment to be supplied is not at or near the end of its life cycle and that replacement components for all control equipment shall be available from the manufacturer for a minimum of fifteen (15) years from the date of installation.

D. Qualification Data: For qualified Installer.

E. Field quality-control reports.

F. Final Acceptance Documentation:

1. As-Built Drawings: With final revisions per Engineer’s comments.
2. Final Record of Completion: Prepared in accordance with NFPA 72.
3. Test Reports: From Pre-Acceptance testing; substantially in the format and inclusive of information required by NFPA 72.

G. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals, include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

    a. Frequency of testing of installed components.
    b. Frequency of inspection of installed components.
    c. Requirements and recommendations related to results of maintenance.
    d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.

H. 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.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician and shall be:

1. Licensed in the State of California and be experienced in the installation of fire alarm systems in buildings similar to the Work described herein and has obtained design and inspection approvals for similar projects from authorities having jurisdiction.
2. Foreman: Provide proof of competence of both their company and the individual foreman that will be assigned to this project, in the area of installing fire detection, alarm, and control systems for at least five (5) years and acceptable to the Owner. Once assigned, the Contractor's foreman shall not be changed without the approval of the Owner.
3. Service Organization shall be capable of providing a minimum NICET Level III certified service technician on-site within 4 hours of a request for on-site service.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system where applicable.

D. 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.

E. All control equipment shall have transient protection devices that comply with the requirements outlined in UL 864 9th Edition, Standard for Control Units for Fire-Protective Signaling Systems.

F. All materials and equipment (initiating devices, notification appliances, etc.) shall be new and unused.

G. All equipment supplied shall be first quality and the manufacturer's best type and latest model capable of complying with all requirements of this specification and shall have been in continuous production and in continuous service in commercial applications for at least one year. Obsolete equipment shall not be used.

H. The requirements and recommendations of the latest published edition of the equipment manufacturers' product datasheets, technical specifications, installation instructions and wiring guidelines shall be followed.

1.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.9 SCHEDULING

A. The Contractor's Foreman shall act as a primary point of contact and responsible-in-charge for coordinating the Pre-Acceptance Test with the other portions of the Work, Owner, and the Engineer.

B. The Contractor's Foreman shall act as primary point of contact and responsible-in-charge for coordinating the Final Acceptance Test with the other portions of the Work, Owner, Engineer and Authorities.

1.10 EXTRA MATERIALS

A. The manufacturer shall provide a suggested spare parts list with firm unit prices maintained for the duration of the manufacturer's warranty period as specified herein, for items such as power supplies, central processor units, fault isolator modules, monitor addressable modules, addressable control relay output modules and other modules that may be long lead replacement items. Firm costs for programming changes shall also be included. Firm prices shall be maintained for one year beyond the duration of the manufacturer's warranty period as specified herein.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Distributors of acceptable manufacturer's equipment shall provide documentation indicating that they are authorized by the manufacturer to distribute and service the equipment and that the manufacturer has stated that they have satisfactorily completed all training courses offered by the manufacturer in relation to the equipment provided.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. The system shall include new control/communications equipment which is UL Listed to operate with the submitted manual fire alarm boxes, heat detectors and smoke detectors, and shall alert building occupants using audible and visible notification appliances, supervise each system for conditions which would impair proper system operation, annunciate such abnormal conditions, and where applicable, control related equipment as indicated on contract documents.

B. ALARM CONDITION

1. The system operation shall be such that the alarm operation of any alarm initiating device shall not prevent the subsequent alarm operation of any other initiating device due to wiring or power limitations.
2. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

    a. Manual stations.
    b. Heat detectors.
    c. Smoke detectors.
    d. Automatic sprinkler system water flow.
    e. Fire standpipe system water flow.
    f. Fire pump running.

3. Fire-alarm signal shall initiate the following actions:

    a. Continuously operate alarm-notification appliances.

        1) Activate Pre-recorded message or Temporal three evacuation signal as required.

    b. Identify alarm at the fire-alarm control unit and remote annunciators.
    c. Transmit an alarm signal to the remote alarm receiving station.
    d. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
    e. Record events in the system memory.

C. SUPERVISORY CONDITION

1. The control unit shall have a “SYSTEM SUPERVISORY” LED and a supervisory signal “ACKNOWLEDGE” switch.
2. Supervisory signal initiation shall be by one or more of the following devices and actions:

    a. Valve supervisory switch.
    b. Duct detectors

3. System trouble signal initiation shall be by one or more of the following devices and actions:

    a. Open circuits, shorts, and grounds in designated circuits.
    b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
    c. Loss of primary power at fire-alarm control unit.
    d. Ground or a single break in fire-alarm control unit internal circuits.

e. Abnormal ac voltage at fire-alarm control unit.
f. Break in standby battery circuitry.
g. Failure of battery charging.
h. Abnormal position of any switch at fire-alarm control unit or annunciator.

D. TROUBLE CONDITION

1. When a trouble condition is detected, the following functions shall immediately occur:

a. An amber "SYSTEM TROUBLE" LED light shall light and the system audible signal shall steadily sound when any trouble is detected in the system. Failure of normal power, opens or short circuits on the signaling line circuits or the notification appliance circuits, disarrangements in system wiring, failure of the microprocessor or any identification module, or system ground faults shall activate this trouble circuit.
b. A trouble signal may be acknowledged by actuating the "ACKNOWLEDGE" switch. This shall silence the control unit trouble buzzer. If additional trouble conditions occur, the trouble circuitry shall resound.
c. During an "alarm" condition, all "trouble" signals shall be suppressed with the exception of lighting the amber "COMMON TROUBLE" LED steadily.
d. The display shall indicate all information associated with the trouble condition, including type of trouble point, it's location within the protected premises, and the time and date of that activation.
e. All system output programs assigned via control-by-event equations to be activated by the particular point in trouble shall be executed, and the associated System Outputs (Trouble Notification Appliances and/or relays) shall be activated.

E. System Alarm, Trouble and Supervisory Signal Actions: Annunciate at fire-alarm control unit, remote annunciators, and transmit the signal to the central station.

F. SYSTEM SUPERVISION

1. All wiring extending from the FACU enclosure to fire alarm system components shall be supervised for opens, shorts and grounds. Systems containing unsupervised wiring of any type shall not be acceptable.
2. The occurrence of any fault shall activate the system trouble circuitry but shall not interfere with the proper operation of any circuit that does not have a fault condition.
3. Incoming 120 VAC line power shall be supervised so that any power failure shall be audibly and visually indicated at the control unit.
4. Batteries shall be supervised so that a low battery condition or disconnection of the battery shall be audibly and visually indicated at the control unit.

G. SYSTEM RESET

1. A "SYSTEM RESET" button shall be used to return the system to its normal state after an alarm condition has been remedied. Printed messages shall provide operator assurance of the sequential steps (i.e.: "IN PROGRESS", "RESET COMPLETED") as they occur, should all alarm conditions be cleared.
2. Should an alarm condition continue to exist, the system shall remain in an abnormal state. System control relays shall not reset. The control unit "ALARM" LED shall remain on. These points shall not require acknowledgment if they were previously acknowledged.

2.3 FIRE-ALARM CONTROL UNIT

A. The FACU shall provide power, English display status, supervision, control, and programming capability for the fire detection and alarm system.

B. The control unit shall be located by the Owner and the Engineer, as shown on the drawings.

C. The control unit shall store a record of alarm and trouble events in a nonvolatile history file. This file shall contain, at least, the most recent 500 events, with time and date of each event. It shall be possible to select the number of events to be viewed in the history file so that the entire file does not have to be downloaded. The history file shall remain intact in the event of a loss of AC and battery power.

D. The control unit shall be modular in construction and receive supervised plug-in component boards to provide system functions as hereinafter specified and/or to accommodate future system expansions.

E. The control unit shall be capable of being expanded in the future to support a minimum of 99 addressable points (inputs or outputs). The control unit shall be capable of being expanded and field reprogrammed at any time up to the predetermined maximum capacity of the system, without the requirement to return the operating system to the factory for program changes. All field programming shall be done by an authorized manufacturer's representative.

F. The control unit shall contain a minimum of two (2) signaling line circuits. Each signaling line circuit shall support a minimum of 99 addressable input devices or addressable monitor modules and a minimum of 10 output devices. All addressable input and output devices shall be capable of being intermixed on the same signaling line circuit.

G. The control unit shall accommodate all addressable input devices in alarm simultaneously and shall be capable of operating all output relays while all inputs are in alarm.

H. A minimum of one (1) signaling line circuit per floor shall be used, with devices equally distributed on each circuit. Each signaling line circuit shall be loaded to no more than 75% of its manufacturer specified capacity. Additional SLCs shall be furnished and installed as necessary to comply with this requirement.

I. The control unit shall supply power and communication protocol signals to the addressable input devices over a single pair of wires per signaling line circuit from the control unit. Signaling line circuits shall be field programmable for Style 6 operation.

J. A minimum of three fault isolator modules shall be used on each signaling line circuit. One fault isolator module shall be installed at the point the SLC leaves the FACU and at the point where new installed Class A SLCs return to the FACU. Fault isolator modules shall be placed in order to minimize loss of addressable devices. Fault isolator modules shall be placed at each floor, where the SLC spans multiple floors. No more than 25 devices shall be installed on a circuit between fault isolators.

K. The control unit shall contain a minimum of one (1) visible (strobe) and one (1) audible notification appliance circuits (NAC) per floor to provide an evenly distributed number of notification appliances per circuit. Visible (strobe) notification appliance circuits shall be

independent from the audible notification appliance circuit. Each circuit's power load shall not exceed 75% of the individual circuit power available from the FACU and new installed circuits shall be Class A circuits. Additional NACs shall be furnished and installed as necessary to comply with this requirement.

L. Power for all notification appliances shall come from integral power supplies in the control unit. Remote power supplies, if needed, shall be of the same manufacturer as the FACU. All locations containing remote control equipment (such as a power supply extender) shall be protected with a smoke detector, in accordance with NFPA 72.

M. At a minimum, the FACU shall contain the following:

1. Display. A minimum 80 character, highly readable, display. Upon input activation, the display shall provide the following indication:

    a. A device address display.
    b. A field programmed English label indicating the location of the device.
    c. An English description of the type of device activated, such as smoke detector, manual fire alarm box, water flow switch, etc.
    d. The status of the input: alarm, supervisory or trouble.
    e. Multiple alarm conditions shall be sequentially displayed automatically at not more than a five (5) second interval until manually acknowledged by priority.

2. Annunciation. Annunciation shall be an integral part of the control system and shall indicate alarm, supervisory and trouble conditions and the corresponding address. The following initiating devices shall be annunciated individually:

    a. Smoke detectors;
    b. Heat detectors; and
    c. Other approved types of automatic fire detection devices.

3. Battery voltage and ammeter readouts shall be available from the LCD display.
4. Once acknowledged, individual alarms shall be viewed by operating a "next-alarm" switch.
5. Communication Ports. Two supervised RS232C communication ports shall be provided to support a printer or MODEM. Each RS232C port output shall be programmable for printer or display output and shall be programmable to provide access to the control unit's EEPROM operating system to perform the following functions:

    a. Listing and indicating status of all field devices.
    b. Capability of performing alarm tests on any or all addressable smoke detectors and contact input devices.
    c. Monitoring of the system from remote locations via printer, terminal, or computer.

6. The control unit shall be provided with a “silent” walk test feature. This feature shall allow for testing of the fire alarm system without activating the notification appliances.
7. Clock. A 24 hour clock shall be provided to continually provide the time of day and day of the week information. During normal standby conditions, the control unit shall display time and date.

8. Any operation of an alarm silence, supervisory silence, trouble silence, acknowledge, lamp test, relay switches, or system reset switch shall cause a display indication of operation with time and date. These operations shall also be recorded in the system's history file.

N. The functional operation of the control unit shall be established by programmable software.

1. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

O. Access and control of the operating program shall be restricted to proper personnel designated by the Owner.

1. The control unit shall have a minimum of three (3) security levels, and they shall be designated: "ELECTRICIAN", "ALARM SYSTEM SERVICE TECHNICIAN", and "MANUFACTURER." Each level shall have individual passwords. Illegal access attempts shall be rejected by the system and shall be displayed and recorded in the history file with time and date.
2. The "ELECTRICIAN" security level shall be the lowest security level and shall only allow access to the system status levels and lists and shall not impair system operation.
3. The "MANUFACTURER" and "ALARM SYSTEM SERVICE TECHNICIAN" security levels shall allow access to the operating system.
4. Accessing a programming function that disables normal system operation shall initiate a trouble sequence.

P. Failure of the CPU(s) in the control unit module or a channel shall light the CPU Error LED and sound the control unit trouble buzzer. Alarms received while the control unit is in this state shall bypass the software and sound the general alarm signals and light the alarm LED.

Q. The channel modules shall be field programmable to report wire-to-wire short conditions as either an alarm or trouble condition.

R. The control unit shall be capable of locating input circuit openings by the associated address and initiate the proper display and trouble sequence.

S. The system response to alarms shall be 2.5 seconds maximum for the first alarm.

T. The control unit shall contain an integral standby battery to provide continuous power in the event of AC power failure.

1. The batteries shall be capable of providing 24 hours of backup power for the system and enough remaining power to operate all notification appliances for 15 minutes at the end of the 24 hour period.
2. The calculations for battery standby shall include a "safety factor" (reserve power estimate) of a minimum 20%.
3. Transfer from AC to battery power shall be instantaneous when AC voltage drops below 85 percent input. Transfer to battery standby shall be indicated by display and recorded in the history file with time and date. The indication shall be "AC OFF".
4. Loss of building power for the system shall automatically and immediately cause transfer of the system to battery power and cause all audible trouble signals to sound. Upon return

of building power, the system shall automatically retransfer thereto, and the batteries shall automatically recharge.

5. During battery operation, the control unit shall process all inputs. However, the display shall provide five (5) seconds of indication for each new input condition, then turn off to conserve battery power.
6. The control unit shall have a dual rate battery charger that shall maintain the batteries in a fully charged condition and shall provide recharge of the batteries to full capacity in forty-eight (48) hours.

U. The control unit shall provide a nonprogrammable DPDT common alarm relay and common trouble relay both with contacts rated 2 AMP at 24 VDC.

V. Output Function Modules. The control unit shall utilize output function modules to control output functions. The modules shall plug into the control unit motherboard. The functions and presence of each module shall be supervised, and "ELECTRICIAN" password shall enable the user to request a list that locates the module by panel and slot within system. All modules shall be individually programmable by circuit as hereinafter specified.

1. Addressable control relays shall be provided for each of the auxiliary functions; field verify quantities and locations.

2.4 Fire Alarm System Power Supplies

A. System primary power

1. Primary power for the FACP and the secondary power battery chargers shall be obtained from a dedicated emergency power circuits. Circuit breakers shall be fitted with a suitable guard, requiring removal of a screw to open, and used only for fire alarm. Each circuit used for fire alarm purposes shall be permanently labeled for function.

B. Secondary power supply

1. Provide sealed gelled electrolyte batteries as the secondary power supply for all fire alarm functions. The battery supply shall be calculated to operate loads in a supervisory mode for forty eight hours with no primary power applied and, after that time, operate in alarm mode for two hours. Fifteen minutes of all call paging will be considered the equivalent of two hours normal paging use. Batteries shall be sized at 125% of the calculated size to compensate for deterioration and aging during the battery life cycle. Battery calculations shall be submitted to justify the battery size.
2. Provide battery charging circuitry for each standby battery bank in the system. The charger shall be automatic in design, adjusting the charge rate to the condition of the batteries. All system battery charge rates and terminal voltages shall be read using the fire alarm control panel LCD display in the service mode, indicating directly in volts and amps. Meters reading in percentage are not acceptable.

C. Equipment power supply capacity for each system shall be based on actual calculated load plus 25% excess capacity.

2.5 WIRING

A. Wiring for the initiating devices, notification appliances and remote 80 character LCD display shall be solid or stranded copper and shall comply with the appropriate sections of NFPA 70, *National Electrical Code*. All system wiring size shall be as determined suitable by the manufacturer and in compliance with the *National Electrical Code*, yet they shall not be any smaller than as specified herein.

B. Conductors shall be minimum #14 gauge solid copper, type thhn, thwn or tfn. All wiring shall be run continuously from device to device. Wiring size shall be increased as required to limit voltage drop in accordance with the lump sum method.

C. Shielded wire shall be used as directed by the FACU manufacturer.

D. All wiring shall be installed in metal raceway.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in low-profile twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

2.7 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detection: Actuated by temperature that exceeds a fixed temperature of 135 deg F or a rate of rise detector. The temperature must be clearly printed on the detector.

C. The detectors furnished shall have a listed spacing for coverage up to 2,500 square feet for use in environments as covered by Factory Mutual and UL (UQGS) and shall be installed according to the requirements of NFPA 72E for open area coverage.

2.8 DUCT SMOKE DETECTORS

A. General Requirements for Duct Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to Fire Alarm Control Panel.
4. Duct smoke detectors shall meet the requirements for photoelectric light scattering type detectors. Duct smoke detectors shall be UL listed for installation in air duct sampling housings for the detection of smoke in HVAC system ducts.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual Indicating Light: LED type indicating detector has operated and power-on status.

2.9 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Speakers: The operation of any automatic fire detector, sprinkler waterflow device or manual fire alarm box shall automatically sound an alert tone followed by voice instructions giving approved information and directions for a general or staged evacuation in accordance with the building's fire safety and evacuation plans.

D. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall or ceiling mounted as indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red.

2.10 Notification Appliance Remote Power Supplies

A. Remote power supplies shall power and supervise a minimum of 4 Class B NACs that shall be capable of synchronization on the same circuit, synchronization with notification appliance circuits on other power supplies, and synchronization with notification appliance circuits connected directly to the FACU.

B. Remote power supplies shall have an auxiliary power output for providing remote power to fire alarm system devices other than notification appliances. Devices to be powered from auxiliary power output shall be approved by the Manufacturer and have been tested by a UL and/or FM.

C. Remote power supplies shall be connected to FACU, supervised by and activated by a dedicated Class A notification appliance circuit or Class A connections from addressable monitor modules and addressable control relay output modules.

D. Remote power supplies shall be supervised for loss of power, brownout, and battery trouble conditions. NACs shall be supervised for wiring faults including, opens, wire-to-wire short circuits and earth faults. Remote power supply Trouble signal(s) shall report on the FACU display. Additionally, remote power supply shall have visible indicators (LEDs) for displaying Trouble signal(s) and indicating which NAC is in Trouble at the power supply.

E. All locations containing remote control equipment (such as a power supply extender) shall be protected with a smoke detector, in accordance with NFPA 72.

2.11 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to circuit-breaker shunt trip for power shutdown.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare and submit a minimum of six (6) complete “Pre-Installation Documentation” submittal packages to the Engineer for review prior to submitting same to local officials (as required) for approval and permit. Resubmit portions or entirety of submittal to address Engineer comments prior to submitting package to local officials (as required) for approval and permit. See Part 1 “Submittals” for submittal content.

B. Obtain Owner approval to deliver materials and begin installation once “Pre-Installation Documentation” review process is complete and necessary local approvals and permits have been secured.

3.3 GENERAL EQUIPMENT INSTALLATION

A. Installation, workmanship, fabrication, assembly, erection, examination, inspection and testing shall be in accordance with NFPA 72 and the local applicable codes.

3.4 MODULE AND REMOTE POWER SUPPLY INSTALLATION

A. Install remote power supplies as indicated on drawings. Obtain Engineer approval for locations not previously identified (and approved) in submittal.

B. Install addressable isolator modules as indicated on drawings. Obtain Engineer approval for locations not previously identified (and approved) in submittal.

C. Install addressable monitor modules as indicated on drawings to supervise and monitor the status of each non-addressable device, such as conventional spot-type heat detectors. Obtain Engineer approval for locations not previously identified (and approved) in submittal.

D. Install addressable control relay output modules as indicated on drawings. Obtain Engineer approval for locations not previously identified (and approved) in submittal.

3.5 INITIATING DEVICE INSTALLATION

A. In general, automatic detectors shall be mounted on the structural ceiling or finished ceiling and not on the bottom or side of any type of construction or structure which extends down from the ceiling. Automatic detectors shall be installed as indicated on the plans and in conformance with all codes and Regulations and these specifications. The detectors shall be installed within five (5) feet of the location shown on the drawings to accommodate construction.

B. Automatic detectors shall be located near points where air currents normally intersect. Detectors shall not be located in the direct path of the draft from an HVAC air supply grille, a door, window, or hallway. Detectors shall be installed a minimum of three (3) feet from an HVAC air supply diffuser, in accordance with NFPA 72.

C. Addressable analog photoelectric smoke detectors shall be installed in areas according to the drawings. Unless otherwise shown on the drawings, detectors shall be spaced at thirty (30) foot centers, and in accordance with NFPA 72 and the manufacturer's installation instructions. Smoke detectors shall only be installed in those environments suitable for proper smoke detector operation.

D. Addressable heat detectors shall be installed in environments appropriate for proper detection in accordance with NFPA 72 and the manufacturer's installation instructions.

E. In un-sprinklered areas where the environment is not suitable for proper operation of addressable heat detectors, conventional spot-type heat detectors shall be furnished and installed. Conventional heat detectors shall be monitored and supervised by addressable monitor modules. Addressable monitor modules shall be installed in an area where the environmental conditions are suitable and the monitor modules' initiating circuits extended to the conventional heat detectors alarm contacts.

3.6 NOTIFICATION APPLIANCE INSTALLATION

A. All wall-mounted combination audible/visible notification appliances shall be mounted such that that the entire strobe lens is not less than eighty (80) inches and not greater than ninety-six (96) inches above the finished floor, or six (6) inches below the finished ceiling, whichever is lower.

B. All strobes shall be synchronized.

C. All audible notification appliances shall sound the fire alarm emergency evacuation signal.

3.7 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Supervisory connections at valve supervisory switches.

2. HVAC interface

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

B. Install framed instructions in a location visible from fire-alarm control unit.

3.9 WIRING

A. The wiring and raceway system for the fire alarm system shall be in accordance with the California Building Code and the California Electric Code. Device and appliance boxes shall be new and low-profile.

B. All raceway shall be electrical metallic tubing (EMT) or rigid conduit. MC cable is not permitted.

C. Furnish metal raceway, wiring, outlet boxes, junction boxes, cabinets, labels and similar devices necessary for the complete installation of the fire alarm system. Wiring shall be of the type as specified herein and recommended by the manufacturer and shall be installed in metal raceway throughout.

D. Fire alarm system wiring within the building shall be installed in metal raceway with steel couplings and box connectors. Cast "LB" or "T" type connectors shall be permitted. An equipment-bonding conductor shall be provided in all flexible metallic raceways.

E. All fire alarm system riser conduits shall be minimum 1-inch in diameter.

F. All wiring shall be installed continuous from device to device.

G. Terminal cabinets with hinged, lockable red covers, by Space Age Electronics, Marlboro, MA, or approved equal shall be provided at all junction points. All conductor splices shall be made on screw-type terminal blocks – wire nuts, butt, crimp or screw type connectors shall not be used.

All terminals within a terminal cabinet shall be properly and permanently labeled. All junction box covers shall be painted red.

H. Raceways containing conductors identified as "Fire Alarm System" conductors shall not contain other conductors, and no AC carrying conductors shall be allowed in the same raceway with the DC fire alarm detection and signaling conductors.

I. The conductors for the notification appliance circuits shall not be installed in the same race-way as the conductors for signaling line circuits unless written certification from the manufacturer is supplied to the Engineer indicating that the inclusion of these circuits in the same raceway is acceptable and that no additional consideration is needed for these circuits.

J. Notification appliance circuits and control equipment shall be arranged and installed so that loss of any one (1) notification appliance circuit shall not cause the loss of any other notification appliance circuit in the system.

K. Color coding of conductors shall be approved by the Owner. Unless otherwise indicated, the color code for all fire alarm system conductors shall be as follows:

1. Signaling line circuits and initiating device circuits shall be red and black. Red shall be positive and black shall be negative. (SLC/IDC)
2. Audible notification appliance circuits shall be blue and white. Blue shall be positive and white shall be negative (NAC).
3. Sprinkler circuits shall be red and black. Red shall be positive and black shall be negative.
4. Smoke detector power circuits shall be brown and violet. Violet shall be positive and brown shall be negative.
5. Auxiliary remote power supply circuits shall be brown and violet. Violet shall be positive and brown shall be negative.
6. HVAC shut-down circuits shall be orange and yellow.
7. Remote annunciator circuits shall be violet and numbered at each end.
8. AC supply circuit to the main FACU shall be white, black and red. The black shall be one phase, and the red shall be the opposite phase, if required. The white shall be the neutral. If a separate feed is required for the battery charger, it shall be black and white unless the main FACU requires only one AC feed. In that case, the conductors to the battery charger shall be red and white.

L. Exposed raceways shall be run parallel and perpendicular to the walls and ceilings. Wherever practical, exposed raceways shall be run on the ceiling as close as possible to a wall or as high as possible on a wall. Where exposed raceways shall cross under a structural beam or rib, they shall be run down on one side of the beam or rib, across its bottom, and up to the ceiling on the other side of the beam or rib. No spanning from beam to beam or rib to rib shall be permitted. The use of a raceway body on one side of a beam or rib shall be permitted provided it shall be readily accessible.

M. Fault isolator modules shall be furnished as required and shall be mounted as directed by the manufacturer. The field location of the fault circuit isolators shall be labeled so that the devices may be easily located, and that location shall be noted on the point-to-point and as-built drawings.

N. All wiring within the control unit shall be neatly served in the panel gutters and be secured by means of Thomas & Betts "Ty-Raps" or by other approved means.

3.10 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.11 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction and Engineer.

B. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
    b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test visible appliances for the public operating mode according to manufacturer's written instructions.
5. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.12 AUTHORITY HAVING JURISDICTION FINAL ACCEPTANCE

A. Prepare and submit a minimum of six (6) complete “Final Acceptance Documentation” submittal packages to the Engineer for review prior to submitting same to local officials for final system

approval. Resubmit portions or entirety of submittal to address Engineer comments prior to submitting package to local officials. See Part 1 "Submittals" for submittal content.

B. Submit reviewed "Final Acceptance Documentation" submittal package to authority and coordinate scheduling (minimum ten (10) business days notice) of common fire sprinkler and fire alarm system acceptance testing. If acceptable to the authority, the reviewed "Approval Documentation" submittal may be submitted to the authority at the time of the final acceptance tests.

C. Demonstrate system components to authority having jurisdiction as necessary.

D. A 60-hour battery test shall be performed if requested by the Authority.

E. Reschedule testing where unsatisfactory results cannot be resolved such that testing can be completed to the satisfaction of the authorities. See Owner "General Agreement" for possible additional costs and penalties.

F. Upon satisfactory completion of the tests, leave the fire alarm system in proper working order.

3.13 PROJECT CLOSEOUT PROCEDURES

A. Prepare and submit a minimum of six (6) closeout documentation packages to the Engineer for review prior to scheduling Owner demonstration and training. Resubmit portions or entirety of submittal to address Engineer comments prior to scheduling demonstration and training. See Part 1 "Submittals" for submittal content.

B. Schedule Owner demonstration and training with the Owner for each building. Provide at least five (5) working days notice.

C. Demonstrate equipment, specialties, and accessories with the Owner. Review operating and maintenance information with the Owner.

1. Electrician & Building Manager: Prior to final acceptance of the fire alarm system, provide operation training to each shift of the Owner's designated Building Manager. Each training session shall be a minimum of 1 hour and shall be conducted on shift or at a time acceptable to the Owner. Each session shall include an overview of the system and the devices connected to it, emergency procedures (including alarm, trouble and supervisory condition procedures), control panel operation, and safety requirements. Each session shall include a complete demonstration of the system.
2. The manufacturer's technical representative shall also be required to instruct designated building and management personnel in the general operation of the system and to give the designated personnel an overview of the system functions when the system is in normal, supervisory mode, alarm mode, and trouble mode, as specified in this specification.

END OF SECTION 283111

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 31 20 00

EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. Specifications for the excavation, filling, recompacting, grading and disposal of excess material.
B. Related Sections
   1. Section 31 23 24, “Trenching and Backfilling”

1.02 REFERENCED STANDARDS

A. ASTM International
   1. ASTM C136-84a: Standard Method for Sieve Analysis of Fine and Coarse Aggregate
   2. ASTM D1557: Laboratory Compaction Characteristics of Soil Using Modified Effort
   3. ASTM D2922: Density of Soil and Soil-Aggregate in Place by Nuclear Methods
B. Caltrans – State of California Standard Specifications; latest edition
C. Geotechnical Investigation and Geologic Hazards Evaluation Laney College Library Learning Resource Center report prepared by Fugro dated February 28,2020

1.03 DEFINITIONS

A. Compaction
   1. The degree of compaction is specified as percent compaction. Maximum densities refer to the maximum laboratory dry soil densities obtainable at optimum moisture content as determined by ASTM D1557.
   2. Percent compaction (relative compaction) is the ratio of the measured field dry density to the laboratory maximum dry density.
B. Excavation Slope: Excavation slope shall be defined as an inclined surface formed by removing material from below existing grade.

1.04 SUBMITTALS

A. Product Data
   1. Fill materials
   2. Source of concrete and aggregate for approval
B. Test Reports
   1. Gradation (ASTM C136)
   2. Density-In-Place (ASTM D2922)

PART 2 - PRODUCTS

2.01 FILL MATERIALS

A. Class 2 Aggregate Base: Class 2 aggregate base for subsequent backfill and/or pavement base to be ¾ inches maximum Class 2 aggregate base conforming to Caltrans, Section 26.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Surplus Material: Unless otherwise specified, surplus excavated material shall be disposed of off-site in accordance with applicable ordinances and environment requirements at the expense of the Contractor.

B. Hauling
   1. When hauling is down over highways or city streets, loads shall be trimmed and the vehicle shelf areas shall be cleaned after each loading.
   2. Loads shall be watered after trimming to eliminate dust.

C. Subgrade: Unless directed otherwise on the drawings, soil subgrades in areas to receive engineered fill, slabs-on-grade, or pavements shall be scarified to a depth of at least 12 inches, moisture conditioned to approximately 3 percent above optimum water content and compacted per the requirements indicated in the plans.

D. Finish Grading
   1. Finish surfaces shall be smooth, compacted and free from irregularities. The degree of finish shall be that normally obtainable with a blade-grader.
   2. Finish grades shall be as specified on the plans, except where a local change in elevation is required to match existing conditions, or to ensure proper drainage.
   3. When the work is at an intermediate stage of completion, lines and grades shall be as specified within 0.1 foot or as necessary to provide adequate drainage.

3.02 FIELD QUALITY CONTROL

A. Fill material shall be placed in horizontal layers and compacted with power tampers, rollers, idlers, or vibratory equipment. Within the upper 5 feet of the finished ground surface, engineered fills shall be compacted to at least 90% relative compaction, as determined by ASTM D1557, or as approved by the Geotechnical Engineer. The upper 6 inches of subgrade soils below pavements shall be compacted to 95% relative compaction or as indicated in the plans. Fill material shall be spread and compacted in lifts not exceeding 8-inches in uncompacted thickness.

3.03 TESTS

A. Inspection Trenches

   1. Owner will direct Contractor to construct inspection trenches in compacted or consolidated backfill to determine that Contractor has complied with these Specifications.

END OF SECTION

SECTION 31 23 19

DE-WATERING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Specifications and procedure for the de-watering of excavations and disposal of water.

1.02 SUBMITTALS

A. Prior to installation of the de-watering system, submit shop drawings and design data indicating the following:
   1. The proposed type of de-watering system
   2. Arrangement, location and depths of system components
   3. Complete description of equipment and instrumentation to be used, with installation, operation and maintenance procedures
   4. Methods of disposal of pumped water
   5. Necessary permits for water disposal

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. Furnish all materials, tools, equipment, facilities, and services as required for providing the necessary de-watering work and facilities.
B. Provide backup equipment as necessary for the replacement and for unanticipated emergencies.

PART 3 - EXECUTION

3.01 DE-WATERING

A. Keep excavation reasonably free from water during construction.
B. Disposal of water shall not damage property or create a public nuisance.
C. Have on hand pump equipment and machinery in good working condition for emergencies and workmen available for its operation.
D. De-watering systems shall operate continuously until trenches are backfilled.
E. Groundwater shall be controlled to prevent softening of the bottom of excavations, or formation of “quick” conditions.
F. De-watering systems shall not remove natural soils.
G. Control surface runoff to prevent entry or collection of water excavations.
H. Release of groundwater shall be controlled to prevent disturbance of the natural foundation soils or compact fill.
I. There shall be no discharge of turbid or hazardous water on site.
J. Discharge or disposal of water shall be controlled to prevent erosion.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 31 23 24

TRENCH EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Perform all excavation, shoring, dewatering, backfilling, compaction, pavement restoration, and grading necessary or required for the construction of the work as covered by these Specifications and indicated on the Drawings. The excavation shall include, without classification, the removal and disposal of all materials of whatever nature encountered, including water and all other obstructions that would interfere with the proper construction and completion of the required work.

B. Related Sections
   1. Section 32 11 23, “Aggregate Base”
   2. Section 32 12 16, “Asphaltic Concrete Paving”
   3. Section 31 23 19 “De-Watering”
   4. Section 33 10 00 “Water Utilities”
   5. Section 33 33 00 “Site Sanitary Sewerage System”
   6. Section 33 40 00 “Storm Drainage System”

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM).
B. State of California, Department of Transportation, Standard Specifications (Standard Specifications) July 1992.
C. State of California, Department of Transportation, Manual of Test (California Test).

1.03 SUBMITTALS

A. Submit the following:
   1. Sheeting and Shoring Plan: Refer to Paragraph 1.05 below.
   2. Potholing Report as described in Paragraph 3.02.
   3. Samples and Test Results: Furnish, without additional cost to the Owner, such quantities of import materials as may be required by the Owner’s Representative for test purposes. Cooperate with the Owner’s Representative and furnish necessary facilities for sampling and testing of all materials and workmanship. Submit test results for import materials. Tests shall have been performed within 60 days of submission. All material furnished and all work performed shall be subject to rigid inspection, and no material shall be delivered to the site until it has been favorably reviewed by the Owner’s Representative, or used in the construction work until it has been inspected in the field by Inspector of Record.

1.04 QUALITY ASSURANCE

A. Source Quality Control: Test import materials proposed for use to demonstrate that the materials conform to the specified requirements. Tests shall be performed by an independent testing laboratory.

B. Field Quality Control:
   1. The Owner will:
      a. Review and test materials proposed for use.
      b. Inspect placement and compaction of fill.
      c. Test soils during placement of fill.
   2. Contractor shall excavate holes for in-place soil sampling. Contractor shall be responsible

for costs of additional inspection and re-resting resulting from non-compliance.

C. Testing Methods:
   1. Durability Index: Manual of Test, State of California, Department of Transportation.
   2. Specific Gravity: ASTM D854.
   3. Laboratory Compaction: ASTM D1557, Method A or C.
   4. In-Place Density: ASTM D2922.
   5. Particle Size Analysis of Soils: ASTM D422.
   6. Plastic Limit and Plasticity Index: ASTM D4318.
   7. Soil Classification: ASTM D2487.
   8. In-Place Moisture Content: ASTM D3017.

1.05 EXCAVATION AND TRENCHING

A. General Protection: Pursuant to Labor Code Sections 6705 and 6707, Contractor shall include in its base bid all costs incident to the provision of adequate sheeting, shoring, bracing or equivalent method for the protection of life and limb which shall conform to the applicable Federal and State Safety Orders.

B. Before beginning any excavation five (5) feet or more in depth, submit to the Owner's Representative a detailed plan showing the design of shoring, bracing, sloping or other provisions to be made for worker protection from the hazard of caving ground during excavations. Comply with the Standards established by the State of California Construction Safety Orders Title 24 of the California Administrative Code. If the detailed plan varies from such shoring system Standards it shall be prepared by a registered civil or structural engineer whose name and registration number shall be indicated on the Drawing. If a dispute arises as to whether the plan must be prepared by a registered civil or structural engineer, the Owner's Representative's determination of the matter shall be final and conclusive. The cost of required engineering services shall be borne by the Contractor and shall be deemed to have been included in the amount of bid for the work as stated in the Agreement.

C. Neither the review nor approval of any plan showing design of shoring, bracing, sloping or other provisions for worker protection shall relieve Contractor from his obligations to comply with Construction Safety order Standards and Title 24 CAC for design and construction of such protective work, and Contractor shall indemnify Owner and Owner's Representative from any and all claims, liability, costs, actions and a cause of action arising out of or related to the failure of such protective system. The Contractor shall defend the Owner, its officers, employees and agents and the Owner's Representative in any litigation or proceeding brought with respect to the failure of such protective systems.

D. The Contractor shall comply with Section 382 of the Civil Code of the State of California relating to lateral, general and sub-adjacent supports wherever structures or improvements adjacent to an excavation may be damaged by such excavation.

E. Contractors must still comply with the State of California Construction Safety Orders, Article 6 – Excavations, Trenches, Earthwork. The requirements of Article 6 apply whether the excavation, trench or earthwork is less than 5', or 5' or more.

F. The Contractor shall select, install and maintain shoring, sheeting, bracing, and sloping as necessary to maintain safe excavations. The Contractor shall be responsible for ensuring such measures: (1) comply fully with 29 CFR Part 1926 OSHA Subpart P Excavations and Trenches requirements, (2) provide necessary support to the sides of excavations, (3) provide safe access to the Engineer's sampling and testing within the excavation, (4) provide safe access for backfill, compaction, and compaction testings, and (5) otherwise maintain excavations in a safe manner that shall not endanger property, life, health, or the project schedule. All earthwork shall be performed in strict accordance with applicable law, including local ordinances, applicable OSHA, CalOSHA, California Civil Code, and California Department of Industrial Safety requirements.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Crushed Rock: ¾-inch maximum crushed virgin drain rock with a minimum durability rating of 58.
B. Bedding Materials: Sand in accordance with the Standard Specifications, Paragraph 19-3.025B.
C. Import Backfill: Class 2, ¾-inch maximum aggregate base, Standard Specifications Section 26. Paragraphs 26-1.06 and 26-1.07 are not applicable.
D. Water: The water used shall be potable and free of objectionable quantities of silt, oil, organic matter, alkali, salts and other impurities. Water quality must be acceptable to the Owner's Representative.
E. Sandy Clay Loam: Provide sandy clay loam backfill in the top 18 inches in unpaved areas, 85% compaction.
    1. Sandy Clay Loam Analysis: Submit a sample of sandy clay loam proposed for use to an accredited Soils Laboratory for "agricultural suitability" analysis report, including particle size, and evaluation of physical and chemical properties of soil and recommendations for adding amendments and fertilizers to the soil.
    2. Upon approval of the Laboratory's report by the Owner's Representative, the recommendations in the report shall become a part of the Specifications and the quantities of soil amendment, fertilizer and other additives shall be adjusted to conform with the report at no additional cost to the Owner. Request Testing Laboratory to send one copy of test results directly to Owner's Representative.
    3. Test Laboratory: Soil and Plant Laboratory, Inc. 352 Matthew Street (PO Box 153), Santa Clara, CA 95052, Tel. (408) 727-0330; or Root Zone Associates, PO Box 18911, San Jose, CA 95118, Tel. (408) 264-7024.
F. Controlled Density Fill (CDF):
    1. Materials:
        a. Cement: ASTM C150, Type II or V. A maximum of twenty (20) lbs. of cement per cubic yard.
        b. Aggregate shall consist of fine aggregate, with our without coarse aggregate, with a maximum size of 1-inch, free of clay, organics, and other deleterious materials. Less than 10 percent by weight shall pass the No. 200 sieve, and materials passing the No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.
        c. Water: Potable.
        d. Fly Ash: ASTM C618, Class F unless otherwise approved.
    2. Mix Design:
        a. Performance Requirements: The CDF shall be proportioned to be a non-segregating, free flowing, self-consolidating, low shrink slurry.
        b. Mix Design Requirements: The Contractor and its supplier shall determine the materials and proportions used to meet the requirements of these Specifications. Design the mixes far enough ahead of placement to allow completion of trail mix testing and submittal of test results. The mix design(s) shall be prepared for the range of aggregate gradations that is expected to be used. The Contractor shall make daily checks of the aggregate gradation and adjust the mix design as required to meet these Specifications.
        c. Material Strength Requirements: The unconfirmed compressive strength at 28 days shall be 100 psi as per ASTM D4832.
G. Concrete: Concrete encasement used for conduit backfill shall be rated 4000 psi at 28 days and shall have red dye additive. Submit mix design for approval.

PART 3 - EXECUTION

3.01 CONTROL OF WATER

A. All excavations shall be kept free from water and all construction shall be in the dry.
   1. It should be presumed that the presence of groundwater will require dewatering operations. Furnish, install, maintain, and operate all necessary pumping and other equipment for dewatering all excavations. At all times have on the project sufficient pumping equipment for immediate use, including standby pumps for use in case other pumps become inoperable.
   2. Provide a sufficient number of pumps so as to hold the groundwater level at an elevation of not less than 1 foot below the lowest elevation of the pipe, duct or other material to be placed.
   3. Dispose of water in such a manner as to cause no injury or nuisance to public or private property, or be a menace to the public health.
   4. The dewatering operation shall be continuous, so that the excavated areas shall be kept free from water during construction, while concrete is setting and achieves full strength, and until backfill has been placed to a sufficient height to anchor the work against possible flotation.
   5. Continue dewatering during backfilling operations such that the groundwater is at least 1 foot below the level of the compaction effort at all times. No compaction of saturated materials will be allowed.
   6. Dewatering devices must be adequately filtered to prevent the removal of fines from the soil.
   7. The Contractor shall be responsible for any damage to the foundations or any other parts of existing structures or of the new work caused by failure of any part of the Contractor's protective works. After temporary protective works are no longer needed for dewatering purposes, they shall be removed by the Contractor.
   8. If pumping is required on a 24-hour basis, requiring engine drives, then engines shall be equipped in a manner to keep noise to a minimum.
   9. Prevent disposal of sediments from the soils to adjacent lands or waterways by employing whatever methods are necessary, including settling basins and holding tanks for disposal off site

B. The Contractor shall be responsible for furnishing temporary drainage facilities to convey and dispose of surface water falling on or passing over the site.

3.02 EXISTING UTILITIES

A. General: The known existing buried utilities and pipelines except building connections are shown on the Drawings in their approximate location. The Contractor shall exercise care in avoiding damage to all utilities, as he will be held responsible for their repair if damaged. There is no guarantee that all utilities or obstructions are shown, or that locations indicated are accurate. Utilities are piping, conduits, wire, cable, ducts, manholes, pull boxes and the like.

B. Check on Locations (Potholing):
   1. Contact the Owner and request them to locate their respective utilities prior to the start of "potholing" procedures. The Owner shall be given 7 days written notice prior to commencing potholing. The Owner has performed a limited investigation and has recorded those findings on the Contract Documents.
   2. Clearly paint the location of all affected utility underground pipes, conduits and other utilities on the pavement or identify the location with suitable markers if not on pavement. In addition to the location of metallic pipes and conduits, non-metallic pipe, ducts and conduits shall also be similarly located using surface indicators and detection tape if present and shall then be similarly marked.
   3. After the utility survey is completed, commence "potholing" to determine the actual location and elevation of all utilities where crossings, interferences, or connections to the new pipelines are shown on the Drawings, or indicated by surface signs. Prior to the preparation of piping shop drawings, or the excavating for any new pipelines or structures, the Contractor shall locate and uncover these existing utilities to a point 1-foot below the utility. Submit a report identifying each

underground utility and its depth and station. Any variation in the actual elevations and the indicated elevations shall be brought to the Owner's Representative's attention.

4. Excavations around underground electrical ducts and conduits shall be performed using extreme caution to prevent injury to workmen or damage to electrical ducts or conduits. Similar precautions shall be exercised around gas lines, telephone and television cables.
5. Excavations shall have surface dimensions of no more than 18" x 18". Air spades and vacuum excavators shall be used to limit the size of excavations and damage to adjacent facilities. Backfill after completing potholing. In existing streets, repave with project typical pavement section or match existing pavement section, whichever is greater.

C. Interferences:
1. If interferences occur at locations other than shown on the Drawings, the Contractor shall notify the Owner's Representative, and a method for correcting said interferences shall be supplied by the Owner's Representative. Payment for interferences that are not shown on the plans, nor which may be inferred from surface indications, shall be in accordance with the provisions of the General Conditions. If the Contractor does not expose all required utilities prior to shop drawing preparation, he shall not be entitled to additional compensation for work necessary to avoid interferences, nor for repair to damaged utilities.
2. Any necessary relocations of utilities, whether shown on the Drawings or not, shall be coordinated with the Owner if instructed to do so in writing from the Owner's Representative.

D. Overhead Facilities: There may be existing overhead electric and telephone transmission lines on the site. These overhead utilities are not shown on the Drawings. Extreme caution shall be used when working in the vicinity of overhead utilities so as to prevent injury to workmen or damage to the utilities. The Contractor shall be required to comply with the applicable provisions of the California Construction Safety Orders when working anywhere on this project.

E. Existing gas, water, sewer and communications laterals are not specifically shown on the Drawings but do exist along the existing utility corridors. Protect all service laterals from damage due to construction operations. If any laterals are damaged, notify the Owner's Representative immediately. The cost of repair shall be borne by the Contractor.

3.03 GENERAL CONSTRUCTION REQUIREMENTS

A. Site Access: Access to the site will be over public and private roads. Exercise care in the use of such roads and repair at the Contractor's expense any damage thereto caused by Contractor's operations. Such repair shall be to the satisfaction of the Owner or agency having jurisdiction over the road. Take whatever means are necessary to prevent tracking of mud onto existing roads and keep roads free of debris. Contractor shall provide access plan for all phases of work for approval by Owner's Representative prior to trenching operations.

B. Traffic Regulation: Provide such flagmen, lighted barricades, flares, lights, warning signs, and safety devices as may be required for control of traffic adjacent to all areas of work. A minimum of one 12-foot-wide lane of traffic shall be kept open at all times.

C. Open Excavations: Provide chain link fence around all excavations left open during non-working hours in unpaved areas. In all paved areas (walkways and fire lanes) excavations left open during non-working hours shall be covered with steel plates.

D. Access: Free access must be maintained to all fire hydrants, water valves and meters, and driveways.

E. Open Trench Limitations: The Owner's Representative shall have the authority to limit the amount of trench to be opened or left open at any one time. In roads, excavation and pipe laying shall be coordinated to the end that a minimum of interference with public traffic will result. Trenches in streets and pathways shall be covered with trench plates at the end of each day. An open trench in existing streets shall be defined as any trench that has not been completely backfilled, satisfactorily compacted, and capped with the permanent pavement.

F. Demolition of Pavement: Where trenching or excavation occurs in paved areas, the pavement shall be scored and broken ahead of the trenching or excavation operation. The extent of paving removed shall be limited to the minimum necessary for the excavation. The final trench repair shall have sawcut edges.
G. Dust Control: Take proper and efficient steps to control dust.

3.04 TRENCH EXCAVATION

A. There is no room on site for storing excavated material. All excavated material shall be disposed of off campus. All backfill material shall be imported.
B. Excavation to the extent shown on the drawings and under the drip line of trees shall be hand excavated to a level below the root zone of the trees – NO EXCEPTIONS.
C. Excavation for pipe and duct shall be in open cut. The trench shall be as wide as necessary for sheeting and bracing and the proper performance of the work up to the maximum width permitted by the typical cross-sections shown on the Drawings. The sides of the trenches shall be vertical in existing streets. The bottom of the trench shall be constructed to the grades and shapes indicated on the Drawings. Should the Contractor desire to use other equivalent methods, he shall submit his method of construction to the Owner's Representative for favorable review prior to its use.
D. Take care not to overexcavate. Accurately grade the bottom of the trenches to provide uniform bearing and support for each section of the pipe at every point along its entire length, except for the portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints, and as hereinafter specified. Dig bell holes and depressions for joints after the trench bottom has been graded, and, in order that the pipe rest on the bedding for as nearly its full length as practicable, bell holes and depressions shall be only of such length, depth and width as required for properly making the joint. Remove stones as necessary to avoid point bearing.
E. Backfill and compact overexcavations to 95% of its maximum dry density with Class II Aggregate Base material. Provide filter fabric (Mirafi, or equal) above, below, and on both sides of aggregate base as directed by the Owner's Representative. There shall be no additional payment to the Contractor for overexcavations not directed by the Owner's Representative. Remove unsatisfactory material encountered below the grades shown as directed by the Owner's Representative and replace as directed. Payment for removal and replacement of such unsatisfactory material directed by the Owner's Representative shall be made in accordance with the provisions of the General Conditions.
F. Grade trenches so that they are uniformly sloped between the pipe elevations shown on the Drawings. Comply with the minimum and maximum trench widths shown on the Drawings. Notify the Owner's Representative if the trench width exceeds the maximum allowable width for any reason.
G. For all piping or conduits to be placed in any excavated and backfilled area, such as at manholes or for building connections, the structural backfill shall be first compacted to a level at least 3 feet above the top of the piping or conduit elevation and then retrenched to pipe grade.
H. Provide ladders for access to the trench by construction and inspection personnel.

3.05 SAFETY BARRICADES AND LIGHTS

A. Where required for protection of workmen, public safety, or as required by State Laws, substantial barricades shall be provided for the areas where excavation, trenching, construction and demolition work are being performed. Safety Barricades shall not be used in lieu of required guardrails on temporary bridges crossing trenches, excavations or other openings. For protection of the *Visually Impaired*, safety barricades shall be joined together with 3" yellow *Caution* tape as follows:
    1. Two strands of caution tape running continuous from barricade to barricade, one at the tops of the barricades and one at a height of from 4" to 12" above grade or

mounting level.

2. In addition battery-operated warning lights shall be maintained on such barricades, whenever visibility is restricted, and at night.

3.06 BACKFILL AND COMPACTION

A. Place bedding and backfill materials true to the lines, grades, and cross-sections indicated on the Drawings and compacted to the degree specified on the Drawings. Place bedding and backfill materials in horizontal lifts not to exceed 8 inches in thickness measured before compaction. The difference in level on either side of a pipe or duct shall not exceed 4 inches.

B. Backfill material shall not be placed over the pipe or duct until after it has been inspected by the Owner's Representative.

C. It shall be incumbent upon the Contractor to protect the pipe or duct from damage during the construction period. It shall be the Contractor's responsibility to repair broken or damaged pipe or duct at no extra cost to the Owner. Tamping of backfill over the pipe shall be done with tampers, vibratory rollers and other machines that will not injure or disturb the pipe or duct. Carefully place backfill around and over the pipe or duct.

D. Do not allow construction traffic nor highway traffic over the pipe trench until the trench backfill has been brought back even with existing adjacent grade.

E. Add water to the backfill material or dry the material as necessary to obtain the optimum moisture content for the compaction shown on the Drawings or specified. If the Owner's Representative determines that the nature of the ground in which the trench lies precludes compaction of the backfill to the specified density, the backfill shall be compacted to the maximum practicable density. Employ such means as may be necessary to secure a uniform moisture content throughout the material of each layer being compacted. After the material has been moisture conditioned, compact it with compaction equipment approved by the Owner's Representative to achieve specified compaction. The Contractor shall be responsible for obtaining the densities specified. Should the Contractor fail, through negligence or otherwise, to compact to specified density, or to backfill and compact to surface grade, thus permitting saturation of the backfill material from rains or from any other source, the faulty material shall be removed and replaced with approved material which shall be compacted to the specified density at optimum moisture content, and no additional payment will be made for doing such work or removal and replacement.

F. Compaction by flooding, ponding or jetting will not be permitted.

3.07 CONTROLLED DENSITY FILL (CDF)

A. Trench Backfill:

1. Contractor can choose to backfill trench with CDF in place of Class II Aggregate Base. (See trench sections on drawings.)
2. CDF shall be placed into the trench so that the CDF is placed evenly to prevent uneven loading of the pipe. CDF shall not be placed directly onto the pipe. The maximum depth of the first lift of CDF shall not allow the pipe to move or float. Subsequent lifts of CDF shall be placed so that that pipe does not shift or float. CDF placed in trenches with steep slopes shall be placed in lifts to prevent flotation of the pipe, and the Contractor shall install approved sand bags as needed to secure the pipe in place during placement of the CDF.
3. The maximum temperature of the CDF shall be 74°F at the time of placement. The minimum temperature of the CDF shall be 40°F at the time of placement. CDF shall be placed in lifts not exceeding 6 inches. Each lift shall be allowed to cure long enough to lose its fluid properties before placing the next lift.

3.08 SUPPORT OF EXCAVATIONS

A. Adequately support excavation for trenches and structures to meet all applicable requirements

in the current rules, orders and regulations. Excavation shall be adequately shored, braced and sheeted so that the earth will not slide or settle and so that all existing structures and all new pipe and structures will be fully protected from damage. Keep vehicles, equipment and materials far enough from the excavation to prevent instability.

B. Take all necessary measures to protect excavations and adjacent improvements from running, caving, boiling, settling, or sliding soil resulting from the high groundwater table and the nature of the soil excavated. Attention is directed to Section 832 of the Civil Code of the State of California relating to lateral and subjacent supports, and wherever structures or improvements adjacent to the excavation may be damaged by such excavation, the Contractor shall comply with this law.

C. The support for excavation shall remain in place until the pipeline, duct or structure has been completed. During the backfilling of the pipeline or structure, the shoring, sheeting and bracing shall be carefully removed so that there shall be no voids created and no caving, lateral movement or flowing of the subsoils.

3.09 FINISH GRADING

A. Except where shown otherwise in the Drawings, restore the finish grade to the original contours and to the original drainage patterns. Grade surfaces to drain away from structures. The finished surfaces shall be smooth and compacted.

3.10 DISPOSAL OF EXCAVATED MATERIAL

A. Dispose of all excavated material offsite in a legal manner.

END OF SECTION

SECTION 31 62 13 – DRIVEN PILES

PART 1 GENERAL

1.01 SUMMARY

A. General: Provide Driven Piles in accordance with requirements of the Contract Documents.

1.02 REFERENCES

A. American Concrete Institute (ACI): ACI 318/318M, "Building Code Requirements for Structural Concrete".

B. American Welding Society (AWS): D1.1, "Structural Welding Code, Steel".

1.03 RELATED WORK SPECIFIED IN OTHER SECTIONS

Submittals	Division 1
Quality Control	Section 01 45 00
Quality Assurance: Structural Testing and Inspection	Section 01 45 05

1.04 SUBMITTALS

A. Procedures: Furnish submittals in accordance with general requirements specified in Section 03 30 00.

B. Shop Drawings: Submit for Architect's action. Furnish shop drawings for the fabrication and installation of the Work. Indicate the piling types, configurations and layouts, including individual piling numbers, reinforcing details, prestressing tendon details, permanent steel shells, splices and driving shoes, and other relevant items. Note pickup points for all piles.

C. Certifications: Submit for Architect's information. Furnish certified reports for the following.

1. Certification to Examination of Site and Records: Before proceeding with the Work, submit certification in acceptable form signed by the Contractor, stating that careful examination has been made of the site, existing structures, records of utility lines, test boring records, soil samples, sub-surface exploration reports by the subsoil exploration consultant, the Drawings and Specifications.

2. Concrete Mix Designs: Furnish certified report identifying the design mixes, stating where each mix will be used, the mix proportions, and additional design information including adjustments for seasonality or flowability of concrete.

3. Concrete Materials and Mixes: Furnish certified test results, including mill certificates, showing that the mix proportions and materials comply with the specified characteristics.

4. Steel Certificates: Furnish certified mill reports covering the chemical and physical properties of structural steel, reinforcing and prestressing components.

5. Plant inspection reports with each shipment that identify the piles, and certify that they meet the design specifications.

E. Quality Control Testing and Inspection Reports

1. Submit for Architect's information. Furnish reports for the specified Source Quality Control and Field Quality Control inspections and tests.

2. In addition, furnish a detailed written description of the pile construction procedures, installation sequences, installation methods and equipment to be used in the Work.

1.05 QUALITY ASSURANCE

A. Contractor's Quality Assurance Responsibilities: The Contractor is solely responsible for quality control of the Work. Comply with the requirements specified in Division 1, QUALITY CONTROL.

1. The Contractor's Soils Consultant: The Contractor shall retain at his own expense, the services of a qualified Soils Consultant to advise him on all foundation piling construction techniques involved in this Work, including the design, checking and approval of all other items pertinent to the Work and construction methods for solution of problems which maybe encountered during the prosecution of the Work. The Consultant shall be primarily concerned with construction methods which will result in finished foundation piling of the required quality and strength and with methods which will prevent settlement and/or damage to surrounding structures, roads, utilities, embankments, etc., both within the property line's and on adjoining properties.

2. The Contractor's Concrete Testing Laboratory: The Contractor shall employ, at his own expense, a testing laboratory to design concrete mixes, conduct tests and submit reports for the design mixes.

B. The Contractor shall be experienced in driving prestressed concrete piles in difficult driving conditions and shall have an experienced pile driving supervisor on the jobsite at all times during the work.

C. Tolerance of fabricated piles shall be as follows:

1. Length: Plus or minus 3/8-inch per ten feet of length.

2. Width: Minus 1/4-inch to plus 1/2-inch.

3. Head: Deviation from plane perpendicular to pile axis plus or minus 1/4-inch per foot of width.

4. Head Surface: Irregularities plus or minus 1/8-inch.

5. Straightness: Deviation from straight line of not more than 1/8-inch per ten feet of length.

6. Reinforcing Steel: Main reinforcement cover, minus 1/8-inch to plus 1/4-inch; spiral spacing, plus or minus 1/2-inch.

D. In the event that any pile is not satisfactory, the Owner’s Representative shall establish remedial work, and the Contractor shall bear the cost of remedy.

E. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Pile materials shall not be ordered nor delivered to the job site, except for pile load test purposes. Until the required load tests have been satisfactorily performed, materials ordered or delivered to the project site prior to verification of the assumed pile length shall be at the Contractor's risk.

B. Deliver materials to the project site in such quantities and at such times to assure the continuity of pile installation operations to the project schedule.

C. Mark each pile's length by painting a horizontal line, at 1' intervals, and the distance from the pile point at 5' intervals.

1.07 PROJECT / SITE CONDITIONS

A. Sub-Surface Soil Investigation Report: The Owner shall make available a report prepared for the purposes of design and indicating the general characteristics of the underlying soil conditions on the site. The report represents all conditions known to the Owner, but is not guaranteed to represent all conditions that may be encountered. The Contractor shall notify the Owner and the Architect immediately if the report appears to be at variance with the actual conditions encountered. The report was prepared by Fugro USA Land, Inc., 1777 Botelho Drive, Suite 262, Walnut Creek, CA 94596

B. Site Survey: The Owner shall make available a survey of the site, existing utilities and existing construction. The survey represents all conditions known to the Owner. Other construction, of which no records are available, may be encountered. The Contractor shall formulate his own conclusions as to the extent of such construction, and shall notify the Owner and the Architect immediately the survey appears to be at variance with the actual conditions encountered.

PART 2 PRODUCTS

2.01 PRECAST CONCRETE PILES

A. Precast Piles: Precast, reinforced and/or bonded prestressed concrete piles of square, circular, or octagonal configuration. Size as required for indicated piling capacity.

B. Concrete Strength: Provide minimum concrete compressive strength of 5000 psi at 28 days. The compressive stress, including prestress, under design load shall not be greater than 0.4 f'c.

C. Curing: Piling shall be cured for a minimum of 28 days before installation.

D. Reinforcing: The piles shall be reinforced in a manner acceptable to the Architect. The top most segment of pile shall have closely spaced spirals as accepted by the Architect.

E. Driving Shoes: Provide on all pile tips, unless otherwise accepted by the Architect. An acceptable shoe shall be connected to the pile section in a manner that no separation from or deterioration of the pile will occur under the installation conditions encountered.

2.02 SPLICES AND DRIVING SHOES

A. Steel Splices and Driving Shoes: Provide ASTM A36 structural steel plate, unless higher grade steel is required by the specific design.

2.03 CONCRETE MATERIALS

A. A. Portland Cement: ASTM C 150, Type I or Type II or Type II/V.

B. Fly Ash: ASTM C618 Class F.

C. Ground Slag: ASTM C989.

D. Water-Reducing Plasticizing Admixtures: ASTM C494, Type A to be used unless otherwise noted.

E. High Range Water-Reducing Admixture (Super Plasticizers): ASTM C494, Type G. May be used if reviewed by Architect.

F. Aggregates: ASTM C33. Aggregates subjected to 5 cycles of the sodium sulfate soundness test ASTM C88 shall not lose more than 15% by weight. Aggregates for the entire job shall come from the same source unless a change is acceptable to the Architect.

1. Fine Aggregates: Natural or artificial hard, clean sand with a minimum Fineness Modulus of 2.5 and a maximum value of 3.0.

2. Coarse Aggregates: Gravel or crushed rock with clean, hard, uncoated particles.

G. Mixing Water: Clean and free from deleterious substances which would impair the Work and in conformance with ASTM C94.

H. Steel Reinforcement Bars: ASTM A615, Grade 60.

I. Cold Drawn Bars for Spirals: ASTM A82.

J. Prestressing Tendons: ASTM A416.

K. Ready-Mixed Concrete: ASTM C94.

L. Miscellaneous Materials or Accessories: Provide as indicated or as required to complete the work.

2.04 CONCRETE MIX DESIGN

A. Contractor's Concrete Testing Laboratory: Design each type of mix required in accordance with ACI 301, either by Trial Mix or Previous Experience methods.

B. Improper Mix: Immediately notify the Architect if, at any time during construction, the concrete resulting from the accepted mix design proves to be unsatisfactory for any reason, such as too much water, lack of sufficient plasticity to prevent segregation, honeycomb, or insufficient

strength. The Contractor's Testing Laboratory shall modify the mix design, subject to the Architect's review, until a satisfactory concrete is obtained.

2.05 SOURCE QUALITY CONTROL

A. Concrete Material Analysis Testing: Perform tests to substantiate compliance with specified requirements for cement, aggregate and admixtures. Certified test reports of tests performed by independent test laboratories employed by product manufacturers or material suppliers will be acceptable. Submit reports identifying the source and manufacturer of cement, aggregate and admixtures, the tests performed and the test results.

1. Portland cement mill test reports.

2. ASTM C33, sieve analysis of fine and coarse aggregate which are representative of the materials to be used throughout the Work.

3. ASTM C88, aggregate sodium sulfate soundness test.

4. Fly ash.

5. Plasticizing admixture.

2.06 OWNER'S MONITORING ACTIVITIES

A. See 01 45 05 Structural Testing and Inspection.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine the areas to receive the Work and the conditions under which the Work would be performed. Contractor shall remedy conditions detrimental to the proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected

3.02 PROTECTION OF EXISTING UTILITIES

A. Before installing piles adjacent to any existing utilities, notify the utility owner to ensure that protective Work will be coordinated and performed by the Contractor in accordance with the requirements of such owner of the utility involved. If any existing service lines, utilities and utility structures to remain in service are uncovered or encountered during these operations, protect from damage and provide support if necessary.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during piling operations, immediately notify the Owner, the Architect, and the utility owner. Cooperate with the Owner and utility owner in keeping their respective services, utilities and facilities in operation. Repair damaged utilities to the entire satisfaction of the Owner and utility owner concerned.

3.03 PILING INSTALLATION, GENERAL

A. Prior to moving equipment on the site a pre-installation conference shall be scheduled by the Contractor. The Contractor, Pile Driving Foreman, Architect, Structural Engineer, Geotechnical Engineer, and Pile Driving Inspector shall be present at the conference. The conference shall discuss the schedule, sequence of the work, driving procedures, acceptance criteria, and pile placement procedures.

B. Equipment: Use equipment of type generally used in standard pile installation practice for the specific type of piling to be provided in the Work. Pile driving hammer size and type able to deliver consistently effective dynamic energy suitable to the pile type and the material into which pile will be driven. Drivers shall not have free-swinging leads. Equip hammer with driving cap capable of protecting the pile head and providing uniform distribution of hammer energy to the pile head. Maintain equipment in first class condition; operate at the required efficiency and capacity.

C. Pile Locations: Carefully locate to the lines and spacing shown. Drive either to the plumb position or exact batter as shown.

1. Do not drive piles until after excavation or fill in the area to be occupied by piles has been completed to the elevation or grade indicated.

2. Do not drive piles within 50' of concrete less than 3 days old.

D. Center of Gravity: Conform to the locations indicated for each group of foundation piles.

E. Driving Procedure: Drive piles to the minimum depth and driving resistance as established by the pile load tests, or as directed by Architect for any individual pile location.

F. Handling and Driving Extra Long Slender Piles: Prevent overstress or leading away from a plumb or true position.

G. Lateral Displacement: If piles or pile groups indicate or are subject to lateral displacement, it may be necessary to drive center piles in a pile group and center pile groups within the structure first, in a sequence as required to prevent such lateral displacement.

H. Pile Cut-Off: After driven to acceptable completion, cut off each pile square at the cut-off grade lines and remove surplus material from the site. Make cut-off surface level, free from distortions or damage due to driving or cut-off procedures. Correct damaged pile heads by acceptable methods.

I. Vibration: Use acceptable methods and procedures to limit pile driving vibrations to particle velocities of 2"/sec.

J. Pile Heaving: If piles heave because of driving other piles nearby, drive the affected piles to either the original resistance, or original tip elevation, or both, as directed.

K. Piles Damaged, Mislocated or Out of Alignment: Withdraw and replace by new piles, or cut off and abandon and install additional piles. The Contractor shall be responsible for additional costs to other related structural components, such as concrete caps and grade beams or reinforcing modifications to caps and grade beams due to piles damaged, mislocated or out of alignment.

L. Impact hammer shall have a minimum driving energy of at least 35,000 foot-pounds per blow with a minimum ram weight of 6,500 pounds.

1. The pile driver shall be of adequate size and capacity to hold the piles on specified locations and to permit driving of piles to required depths without interruption.

2. Hammer to be a single acting diesel hammer with a working energy of at least 70,000 foot pounds.

3. Leads

a. Leads shall be fixed, held in position at or near the top and at or near the bottom except where swing leads are approved.

b. Leads shall enable hammer to deliver impacts concentrically without inducing bending moments in the pile.

c. Leads to be parallel and shall not deviate from a straight line by more than 1/2-inch in fifteen feet.

d. Provide leads of sufficient length to accommodate the combined length of pile and hammer.

e. Provide a "barber pole" measuring system so that the hammer stroke is easily observed by the Geotechnical Engineer.

f. Leads to be equipped with extensions to hold the hammer and pile in alignment when the hammer is operating below the bottom of the leads.

4. Driving equipment that damages the piles shall not be used.

5. Cushion

a. Pile heads shall be protected by a minimum 10 inch thick, maximum 15 inch thick cushion of plywood.

b. Pile cushion shall be replaced when smoking, charred, compressed more than 65% of original thickness, spongy or otherwise deteriorated.

M. Indicator Pile Installation

1. Drive indicator piles at the locations and to the depths specified by the Geotechnical and Structural Engineer.

2. The indicator piles shall be driven with the same equipment that is to be used for driving the remainder of the piles.

3. Provided that the indicator piles conform to the requirements of these specifications, they may be cut off and become a part of the completed structure.

N. Indicator Pile Testing

1. During driving, all of the 5 indicator piles shall be evaluated using Pile Driving Analyzer (PDA) equipment. The PDA testing shall be performed in the

presence of the Geotechnical Engineer. The details of the PDA system and methods are described in ASTM D4945 and in Chapter 13 of the "Pile Buck Annual." The PDA shall measure the stresses and accelerations on the pile during driving and provide information on:

a. The efficiency and effectiveness of the pile hammer.

b. Losses in the pile cap, cushion and other driving equipment.

c. Stresses in the pile.

d. Soil resistances (and distributions of soil resistance) during driving.

2. The Contractor shall provide two (2) Case Pile Wave Analysis Program (CAPWAP) analyses of the hammer blows for each of the 5 piles selected for PDA testing. The CAPWAP analyses provide information about load transfer along the pile and the soil damping parameters. The results of the CAPWAP analyses shall be included in the report for the PDA evaluations.

O. Indicator Pile Restriking

1. Each of the indicator piles shall be restruck no sooner than 12 hours nor later than 36 hours after the completion of the initial driving. Restrikes shall be performed with a fully warmed and functioning hammer and the restruck pile shall be advanced at least 6 inches or struck with 50 full-energy-rated blows.

2. The Contractor or Geotechnical Engineer shall provide PDA evaluation for all of the 5 indicator piles during restriking. The Contractor shall provide 10 CAPWAP analyses, one for a selected blow for each of the 5 selected indicator piles. Additional CAPWAP analyses may be requested by the Geotechnical Engineer. Additional CAPWAP analyses will be paid for as additional work.

3. Items considered incidental to restriking indicator piles include, but are not limited to:

a. Moving pile-driving rig to indicator piles selected for restriking.

b. Providing correct alignment of pile hammer and pile.

c. Measuring location of pile at completion of restrike.

P. Pile Driving Criteria

1. Drive piles to the depth shown on the Drawings. The pile depth shown on the Drawings and hence the final pile tip elevation will be confirmed or modified based on the results from the indicator piles.

2. Piling shall be driven continuously without interruption to the final tip elevation.

3. Piling shall be driven to final tip elevation specified or to practical refusal in the dense sand underlying the site. As preliminary criteria, practical refusal may be defined as 10 blows or more penetration resistance in the final inch of driving. Final criteria will be determined once details of the actual pile driving equipment have been confirmed by the Contractor and the results of the indicator pile

program have been analyzed. The final tip elevation is subject to the approval of the Geotechnical Engineer according to his interpretation of sub-surface conditions and the performance of the pile-hammer

4. Redrive or retap piles as directed. No additional compensation will be allowed for redriving or retapping.

5. Survey the tips of all piles immediately after driving and at the completion of driving all piles within a pile cap. Re-drive all piles, which have heaved more than 1/2-inch above or below previous tip elevation.

6. Any pile damaged by reason of internal defects or made unacceptable by improper driving shall be replaced at the Contractor's expense.

7. Any void produced in the upper soils around the pile during pile driving shall be backfilled.

8. When resistance to penetration is low at the tip the pile hammer energy should be reduced so as to minimize tensile stresses in the pile.

3.04 PRECAST CONCRETE PILES

A. Driving Force: Not less than minimum driving energy when operating at not less than 75% efficiency as established by the pile load test program.

B. Driving Procedure: Place piles in prebored holes to depth indicated, where noted, and then drive to final depths and driving resistances.

C. Maximum Deviation from Indicated Locations: 3" from theoretical location at pile cut-off elevation. Center lines of piles plumb within a tolerance of 4", measured when pile is above ground in the leads.

D. Cut-Off: Cut off concrete and reinforcing level to elevations indicated. Remove damaged concrete and reinforcing and replace, as required, to indicated cut-off elevation.

3.05 FIELD QUALITY CONTROL

A. Pile Load Tests

1. A minimum of 3 test piles shall be driven, for each capacity of piles, and 2 such piles shall be selected for load testing at the direction of the Architect. At least 2 piles shall be load tested for each: pile type and/or capacity.

2. Load test piles shall not be permanent piles of the structure. Install with the same equipment and in the same manner as the permanent piles, to estimated tip elevations and driving resistances in the soil which will develop the required piling capacities as noted on the Drawings and in accordance with the geotechnical parameters of the Subsoil Exploration Report.

3. Test piles shall be loaded with a maximum load of twice the stipulated allowable design capacity for a pile type, applied in increments of 25% of the allowable pile load. The allowable design load shall be reached in not less than 8 hours, and shall be maintained 24 consecutive

hours. The total test load shall be reached in not less than 8 hours after the first overload increment has been applied and shall be maintained for at least 24 hours. Unloading shall be in 4 equal steps of 50% of the design load. No load increase shall be applied before pile settlement becomes negligible. Test loads may be applied either by the use of hydraulic jacks reacting against a system of anchor piles or a gravity load arrangement. Anchor piles shall be at least 8' from the test pile. Anchor piles shall not be utilized as permanent building piles. The jack shall be centered on the axis of the pile and shall be of design and maintained in such a condition that it will develop the required test loads, maintain them and release them as specified herein. The test pile will be acceptable for the stipulated piling capacity if the total net settlement, after deducting the rebound, does not exceed 0.01"/ton of test load nor 1/2".

B. Contractor's Pile Surveys: Perform surveys to obtain accurate information of following items for each pile.

1. Survey pile locations daily and submit reports for review. Measure horizontal location of top of pile at the final cut-off elevation.

2. Make a continuous survey of completed piles and record the heave of each pile due to installation of adjacent piles. Submit record of heave survey on a daily basis.

3.06 OWNER'S MONITORING ACTIVITIES

1. See 01 45 05 Structural Testing and Inspection for Owner's Monitoring Activities.

END OF SECTION 31 62 13

SECTION 320100

LANDSCAPE MAINTENANCE PERIOD

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Weed Control and Prevention.
   2. Pest Control and Prevention.
   3. Disease Control and Prevention.
   4. Fertilization.
   5. Pruning of Plant Material.
   6. Replacement of Dead or Unhealthy Plant Material.
   7. Repair of Staking and Guying System.
   8. Watering Plant Material.
   9. Mowing.
   10. Monitoring, Adjustment and Repair of Irrigation System.
   11. Monitoring Changing Soil Moisture and Weather Conditions Relative to Plant Material Water Requirements.
   12. Adjusting Length of Watering Cycles According to Changing Soil and Weather Conditions.

B. For Irrigation, see Section 32 8400.

C. For Grasses, see Section 32 9200.

D. For Soil Preparation and Soil Mixes, see Section 32 9113.

E. For Planting Area Finish Grading, see Section 32 9119.

F. For Plant Material, see Section 32 9300.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance” or “accepted” are used herein, they mean acceptance of District’s representative in writing.

B. IPM — Integrated Pest Management: An approach to pest control that utilizes regular monitoring to determine if and when treatments are needed and employs physical, mechanical, cultural, biological and educational tactics to keep pest numbers low enough to prevent intolerable damage or annoyance. Least-toxic chemical controls are used as a last resort.

1.3 REFERENCES

A. ANSI — American National Standards Institute:
   1. Z60.1 — American Standard for Nursery Stock. Most current edition.

2. A300 – Pruning. Most current edition.

B. NAA — National Arborist Association:

C. Pruning Standards for Shade Trees. Most current edition.

D. ICBN — International Code of Botanical Nomenclature.

E. ICNCP — International Code of Nomenclature of Cultivated Plants.

F. ISA — International Society of Arboriculture.

1.4 SUBMITTALS

A. Product Purchase and Delivery Documentation:
1. Fertilizer: Within 5 working days of each application submit purchase orders, invoices and receipts showing supplier name and address, person who sold product, date of purchase, specific product purchased, quantity purchased, and delivery date.

B. Manufacturer's Current Printed Instructions:
1. Fertilizer.
2. Required chemicals.

C. Documentation of Accepted Conditions: Within 7 working days after District's acceptance of maintenance, submit color photographs and a written report documenting the accepted conditions of the plant material.

D. Inspection Reports:
1. Monthly plant inspection report documenting signs of stress.

1.5 QUALITY ASSURANCE

A. Contractor Qualifications:
1. Maintenance Contractor: Minimum 10 years experience in maintenance of commercial landscape projects.
2. Maintenance Supervisor: Minimum of 10 years experience in landscape maintenance supervision, with experience and training in integrated pest management, turf management, entomology, pest control, soils, fertilizers and plant identification.
3. Labor Force: Thoroughly familiar and trained in the work to be accomplished and perform the task in a competent, efficient manner acceptable to the District.
4. Supervision: Directly employ and supervise the Work force at all times.

B. Notification of Change in Supervision: Notify District of changes in supervision.
1. Identification: Provide proper identification for landscape maintenance firm's labor force.

C. Regulatory Requirements:
1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.
2. Provide for inspections and permits required by Federal, State, or local authorities in furnishing, transporting, and installing of chemicals.

3. Submit a record of herbicides, insecticides and disease control chemicals used to the County Agricultural Commissioner's Office as required by law.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Plant Material: Meet requirements of Section 32 93 00.

1.7 SITE CONDITIONS

A. Environmental Requirements:
   1. Do not apply chemicals during windy conditions.

1.8 SEQUENCING AND SCHEDULING

A. Work Schedule:
   1. Perform maintenance during hours accepted by District.
   2. Be present at the project site at least once a week and as often as necessary to perform specified maintenance.

B. Chemical Applications:
   1. Notify District in advance of required chemical applications.
   2. Obtain District's approval of application schedule.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Gro-Power Products:
   1. Gro-Power Co. – www.gropower.com.
   2. Or approved equal.

B. Other Fertilizers:
   1. Agri Tab Corporation – www.agritab.com.
   2. Delta Bluegrass Company, www.deltabluegrass.com.
   3. Or approved equal.

C. Rock Mulch:
   1. Lyngso. – www.lyngsogarden.com
   2. Or approved equal.

D. Herbicide:
   1. Avenger Organic – www.avengerorganics.com.
   2. Or approved equal.

E. Polymer:
   1. Complete Green, El Segundo, CA, www.completegreencompany.com
   2. Or approved equal.

2.2 MATERIALS

A. Replacement Plant Material:
   1. Match existing genus, species, cultivar and size.
   2. Meet requirements of Section 32 9300.
   3. Meet requirements of ANSI Z60.1, ICBN and ICNCP.

B. Seed or Sod: Match existing genus, species and cultivar.

C. Fertilizers:
   1. Gro-Power Plus 5-3-1.
   2. Gro-Power Hi-Nitrogen (14-4-9) and Gro- Power Premium Hi-Nitrogen 18-3-7.
   3. Gro-Power Controlled Release 12-8-8.
   4. Bolero Lawn Food.
   5. Or approved equal.

D. Fertilizer Tablets for Replacement Plants:
   1. Gro-Power 21 Gram Planting Tablets 20-10-5.
   2. Or approved equal.

E. Gypsum: Agricultural grade product containing 80-percent minimum calcium sulfate.

F. Herbicides, Insecticides, and Fungicides:
   1. Legal commercial quality non-staining materials with original manufacturers' containers, properly labeled with guaranteed analysis, least toxic required.

G. Mulches:
   1. Same as original installation.

H. Polymer: Soil drain / PAM.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection of Existing Conditions:
   1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant materials and walks on or adjacent to the site of the Work.
   2. Provide barricades, fences or other barriers to protect existing conditions from damage during maintenance operations.
   3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants.
   4. Submit written notification of damaged plants and structures to District and District's representative immediately.

3.2 GENERAL MAINTENANCE

A. Maintenance Period for Trees, Shrubs, Groundcover, Vines, Perennials, Grasses, Turf Lawn and Hydroseeded Grasses: Continuously maintain each plant and each portion after

installation, during progress of work, and for a minimum period of 90 days after Final completion until District accepts maintenance.

B. Integrated Pest Management: Employ principles of integrated pest management for each aspect of maintenance.

3.3 TREE AND SHRUB MAINTENANCE

A. Watering:
   1. Using a soil sample tube, check rootball moisture and surrounding soil moisture at representative plants at least twice a week.
   2. Maintain watering basins around trees and shrubs so that enough water can be applied to establish moisture through root zones.
   3. In rainy season, open basins to allow surface drainage away from the root crown where excess water may accumulate.
   4. Restore watering basins at end of rainy season.
   5. Adjust frequency and length of time for watering cycles according to changing soil and weather conditions.
   6. For supplemental hand watering of watering basins, use a water wand to break the water force.
   7. Do not permit crown roots to become exposed to air through dislodging of soil and mulch.
   8. Maintain depth of mulch to reduce evaporation and frequency of watering.

B. Settled or Leaning Plants: Reset plants to proper grades or upright position.

C. Weed Control:
   1. Keep mulched areas between plants and watering basins weed free.
   2. As a last resort use least toxic herbicides.
   3. Avoid frequent soil cultivation that destroys shallow roots.

D. General Pruning:
   1. Meet requirements of Pruning Standards for Shade Trees.
   2. Prune trees to eliminate diseased or damaged growth.
   3. Reduce toppling and wind damage by thinning out crowns.
   4. Prune trees to maintain growth within space limitations, maintaining a natural appearance and balancing crown with roots.
   5. Retain lower branches in a “tipped back” or pinched condition to promote caliper trunk growth.
   6. Do not cut back to fewer than six buds or leaves on branches.
   7. Prune damaged trees or those that constitute health or safety hazards at any time of year.
   8. Make cuts clean and close to the trunk, without cutting into the branch collar.
   9. Make larger cuts (one inch in diameter or larger) parallel to shoulder rings, with the top edge of the cut at the trunk or lateral branch.

E. Fertilizing Acid Loving Plants:
   1. Feed 1 tablespoon of 3-12-12 fertilizer per each foot width of plant.
   2. Spread evenly around plant and water thoroughly.

3. Start feeding when buds have formed until the plant is finished blooming at approximately 4 week intervals.

F. Replacement of Plants: Replace, without cost to District, and as soon as weather conditions permit, plants not in a vigorous, thriving condition, during and at the end of the maintenance period.

3.4 GRASSES MAINTENANCE

A. First three weeks after installation.

1. Watering:

a. For the first three weeks after installation, keep the sod and soil moist throughout the day but never allow the soil to become soggy.

b. Apply water slowly so as to penetrate the entire root zone, without erosion of soils. Pending weather and soil conditions, water four to six times during the day, for approximately five to six minutes each time until roots have become fully established. Adjust watering length and cycle as required to not overwater or underwater the turf. If water is standing under the sod for more than a few minutes after an irrigation set has finished or if the soil is soggy, reduce the amount of water being applied.

c. Root establishment will usually begin within seven to fourteen days depending on the time of year and microclimate.

d. Reduce the frequency of watering cycles just before the first mowing to allow the soil to firm up prior to the first mowing.

e. Water at night or early mornings.

2. Mowing:

a. Approximately 14 days after the sod has been installed, mow approximately 1/3 of the grass blades.

B. Three weeks and beyond after installation:

1. Watering:

a. Reduce the frequency of watering at a gradual pace.

b. Validate the establishment of roots by pulling up a corner of the sod. Once resistance is found, eliminate the last irrigation set of the day. Adjust accordingly in response to temperature, length of day, season, rainfall and soil types.
c. Once the roots have gotten firmly established, add a couple minutes to each irrigation
d. After approximately a week, repeat process until you are watering once a day.

2. Mowing:

a. Mow when turf is dry.

b. Mow with a “mulching rotary lawn mower”.

c. Mow as required to maintain height of 3 to 4 inches.

d. Never remove more than 1/3 of leaf blade per mowing cycle.

C. Amendments and Fertilization During Growing Season:

1. Four to Six weeks after installation, fertilize with Bolero Lawn Food according to manufacturer's current printed instructions.
2.
3. Allow for 10 pounds of gypsum per 1000 square feet for every 4 weeks after planting until Owner accepts maintenance. Apply gypsum by hand or tractor mounted broadcaster. Contingent upon season, application may not be necessary. Confirm with Landscape Architect prior to installation. If not used, submit credit to District.
4.
5. Apply evenly over planting areas by spreading half in one direction and half in a direction 90 degrees to the first direction to assure even application.
6.
7. Apply with either a broadcast centrifugal or gravity spreader.
8.
9. Water thoroughly after application.

D. Resodding of Grass Areas: Resod without cost to District, and as soon as weather conditions permit, grass areas not in a vigorous, thriving condition, during and at the end of the maintenance period.

3.5 INSECTS, PESTS, AND DISEASE CONTROL

A. General:
1. Employ principles of IPM in the selection of preventative and control measures for plant pests and diseases.
2. Insignificant pests will be tolerated providing they do not seriously threaten planting health and appearance.
3. Monitor the site closely and take timely action to address problems identified.
4. Use personnel licensed and experienced using materials approved by the EPA and conform to applicable laws, codes and regulations, under the direction of a licensed certified pest control operator.
5. Spray with extreme care to avoid hazards to any person, pet, or automobile in the area or adjacent areas.
6. Meet requirements of chemical manufacturer's current printed instructions.
7. The Contractor shall be held liable for plant damage due to the use of chemicals.

B. Inspection:
1. Inspect plant material weekly for signs of stress and damage.
2. Submit a written and photographic inspection report of findings monthly to Owner and Owner's representative.
3. Spraying:
4. When necessary apply the least toxic chemical required for the existing problem.
5. Apply in strict accordance with manufacturer's current printed instructions.

C. Apply sprays only if a pest or disease is a serious threat and cease application after problem is under control.

3.6 IRRIGATION SYSTEM

A. Damages:
   1. Repair without charge to District damages to system caused by Contractor's operations.
   2. Perform repairs within one watering period.

B. Cleaning and Monitoring the System:
   1. Continually monitor the irrigation systems to verify that they are functioning properly as designed.
   2. Clean filters and strainers at least once a month and as often as necessary to keep the irrigation systems free of sand and other debris.
   3. Set and continuously adjust and program automatic controller for seasonal water requirement.
   4. Make program adjustments as required by changing field conditions.
   5. At least once a week, daily when required, use a soil sampling tube to check the rootball moisture of representative plants as well as the surrounding soil.
   6. Prevent spraying on windows, building walls, and game courts, etc. by balancing the throttle control on the remote control valves and the adjustment screws on the sprinkler heads.
   7. Do not allow water to atomize and drift.

3.7 FIELD QUALITY CONTROL

A. Maintenance Review:
   1. At the end of the maintenance period, request a review by the District's representative to determine whether maintenance Work meets the requirements of the Contract Documents.
   2. Submit a written request at least five working days prior to the anticipated date of review.
   3. If it is found that the maintenance Work does not meet the requirements of the Contract Documents, the Contractor will receive written notification from the District's representative of corrective Work preventing District acceptance of the maintenance Work.
   4. Perform corrective Work within ten calendar days after the review.
   5. Upon completion of the corrective Work, request another review to determine whether the maintenance Work meets the requirements of the Contract Documents.
   6. Corrective Work followed by review will be required until the corrective Work is found by the Owner's representative to meet the requirements of the Contract Documents.

B. Payment for Additional Maintenance Review Field Trips: If additional trips are required after the first review because of incomplete work, reimburse District for expenses and fee required to have District's representative make additional field trips.

C. District's Acceptance of Maintenance:
   1. When the District's representative determines that the maintenance Work conforms to the requirements of the Contract Documents the Contractor will receive written notification designating the day which the District will accept maintenance responsibility.

2. Continue maintenance of landscape Work until the District accepts maintenance.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 32 11 23

AGGREGATE BASE

PART 1 - GENERAL

1.01 SUMMARY

A. Specifications for furnishing, spreading, and compacting aggregate base course for pavements as indicated.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
ASTM D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D3017 Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

B. State of California, Department of Transportation (Caltrans), Standard Specifications:
Section 17 Watering
Section 26 Aggregate Bases

C. State of California, Department of Transportation (Caltrans), Standard Test Methods:

Calif. Test 201	Method of Soil and Aggregate Sample Preparation Aggregates
Calif. Test 202	Method of Tests for Sieve Analysis of Fine and Coarse Aggregates
Calif. Test 205	Method of Determining Percentage of Crushed Particle
Calif. Test 216	Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates
Calif. Test 217	Method of Test for Sand Equivalent
Calif. Test 229	Method of Test for Durability Index
Calif. Test 301	Method of Test for Resistance “R” Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilometer

PART 2 - PRODUCTS

2.01 AGGREGATE BASE MATERIAL

A. Class 2 aggregate base shall be free of vegetable matter and other deleterious substances. Coarse aggregate, material contained on the No. 4 sieve, shall consist of material of which 25 percent by weight shall be crushed particles as determined by California Test Method No. 205. Class 2 aggregate base shall conform to one of the following gradings, determined in accordance with California Test Method No. 202:

Percentage Passing Sieves

Sieve	3/4 inch Maximum
2 inch	—
1 ½ inch	—
1 inch	100
3/4 inch	90-100
No. 4	35 - 55
No. 30	10 - 30
No. 200	2 - 9

B. Class 2 aggregate base shall conform to the following additional requirements:

Tests	Test Method No. Calif.	Requirements
Resistance (R-Value)	301	78 min.
Sand Equivalent	217	22 min.
Tests	Test Method No. Calif.	Requirements
Durability Index	229	35 min.

2.02 SOURCE QUALITY CONTROL

A. Submit certificate of compliance for approval prior to installation of material.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Call for an inspection by the Engineer and obtain written acceptance of the prepared subgrade or subbase before proceeding with the placement of aggregate base course.
B. The subgrade or subbase to receive aggregate base course, immediately prior to spreading, shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.02 INSTALLATION STANDARDS

A. Aggregate base course shall be applied over the prepared subgrade or subbase and compacted in accordance with Section 26 of the Caltrans Standard Specifications.
B. Aggregate base course shall be minimum uniform thickness after compaction of dimensions indicated. Where not indicated, compacted thickness shall be six inches for driveways/sidewalks and eight inches for roadways.
C. All compaction expressed in percentages in this section refers to the maximum dry density as determined by California Test Method No. 216.

3.03 SPREADING OF MATERIAL

A. Aggregate for base course shall be delivered as uniform mixture of fine and coarse aggregate and shall be spread in layers without segregation.
B. Aggregate base course material shall be free from pockets of large and fine material. Segregated materials shall be remixed until uniform.
C. Aggregate base material shall be moisture-conditioned to near optimum moisture content in accordance with the applicable requirements of Section 17 of the Caltrans Standard Specifications.
D. Aggregate base course six inches and less in thickness may be spread and compacted in one layer. For thicknesses greater than six inches, the base course aggregate shall be spread and compacted in two or more layers of uniform thickness not greater than six inches each.

3.04 COMPACTING

A. Relative compaction of each layer of compacted aggregate base material shall be not less than 95 percent as determined by California Test Method No. 216.

B. Thickness of finished base course shall not vary more than 3/4 inch from the indicated thickness at any point. Base which does not conform to this requirement shall be reshaped or reworked, watered, and recompacted to achieve compliance with specified requirements.
C. The surface of the finished aggregate base course at any point shall not vary more than 3/4 inch above or below the indicated grade.

3.05 FIELD QUALITY CONTROL

A. Perform field tests in accordance with ASTM D2922 to determine compliance with specified requirements for density and compaction of aggregate base material, and with ASTM D3017 to determine moisture-content compliance of the installed base course.

END OF SECTION

This Page Intentionally Left Blank

SECTION 32 12 16

ASPHALTIC CONCRETE PAVING

PART 1 - GENERAL

1.01 SUMMARY

A. Specifications for providing asphaltic concrete paving as indicated.

B. Related Sections

1. Section 32 11 23, “Aggregate Base”

1.02 REFERENCES

A. State of California, Department of Transportation (Caltrans), Standard Specifications

Section 39	Asphalt Concrete
Section 92	Asphalts
Section 93	Liquid Asphalts
Section 94	Asphaltic Emulsions

B. State of California, Department of Transportation (Caltrans), Standard Test Methods

Calif. Test 202	Method of Tests for Sieve Analysis of Fine and Coarse Aggregates
Calif. Test 304	Method of Preparation of Bituminous Mixtures for Testing
Calif. Test 366	Method of Test for Stabilometer Value
Calif. Test 375	Determining the In Place Density and Relative Compaction of AC Pavement

1.03 PROTECTION

A. Protect concrete pavements and walks, curbs and bases, and other improvements adjacent to the operations with suitable materials. The Contractor shall be responsible for any damage caused by the Contractor’s employees or equipment and shall make necessary repairs. Building and other surfaces shall be covered with paper or other protection, where required. All damage caused by the Contractor’s operations shall be prepared or replaced as required.

PART 2 - PRODUCTS

2.01 BASE COURSE MATERIAL

A. Class 2 Aggregate Base. Percentage composition by weight of aggregate base material shall conform to the 3/4 inch maximum grading when determined by California Test 202.

2.02 TACK COAT

A. Tack Coat: Diluted SS-1 or SS-1h emulsion or undiluted RS-1 emulsion in conformance with Section 94 or the Caltrans Standard Specifications.

2.03 ASPHALT PAVING MATERIALS

A. Paving Asphalt: All purpose, aged residue, steam refined, PG 64-10 grade, in accordance with Section 92 of the Caltrans Standard Specifications.

B. Aggregate: Type A, with the grading of the combined aggregate conforming to 1/2 inch maximum size, medium grading, as specified in Section 39 of the Caltrans Standard Specifications.
C. Mixing Facilities: Asphalt concrete surfacing material shall be furnished from an approved commercial asphalt central mixing plant.

2.04 SOURCE QUALITY CONTROL

A. Contractor shall submit Certificate of Compliance from manufacturer for approval prior to installation.

PART 3 - EXECUTION

3.01 PLACING OF BASE COURSE

A. The Contractor shall call for an inspection by the Engineer and obtain written approval of the subgrade before proceeding with the base course.
B. Base course shall be minimum uniform thickness after compaction of dimensions indicated.
C. Base course shall be placed over finished subgrade and compacted in accordance with Section 32 11 23 - Aggregate Base.
D. After base course has been completed, the Contractor shall call for an inspection by the Engineer and obtain written approval before proceeding with application of the asphalt wearing surface.

3.02 PLACING OF TACK COAT

A. The Contractor shall call for an inspection by the Engineer and obtain written approval of the subgrade before proceeding with the tack coat.
B. The tack coat shall be applied using a calibrated distributor truck spray bar, hand spraying, squeegee and brush application in locations where required and per manufacturers requirements. Tack coat shall be applied in accordance with Section 39-4 of the Caltrans Standard Specifications at the rate of from 0.22 to 0.28 gallons per square yard.

3.03 PLACING ASPHALT CONCRETE

A. Areas to be paved shall be covered with a layer of hot asphalt concrete surfacing not to exceed 3.0 inches after compaction.
B. Paving asphaltic concrete shall be delivered, laid, rolled, and finished in accordance with Section 39 of the Caltrans Standard Specifications.
C. Before placing asphalt concrete, a tack coat (paint binder) shall be applied to all vertical surfaces against which asphalt concrete surfacing will be placed. Tack coat shall be applied in accordance with Section 39-4 of the Caltrans Standard Specifications at the rate of from 0.02 to 0.10 gallons per square yard.
D. Finish surface of the wearing course shall be thoroughly compacted, smooth, and free from ruts, humps, depressions, cold joints, or other irregularities.
E. Finish paving shall conform to slopes, lines, and finish grades indicated, and shall drain properly. Where adjacent surfaces are intended to be flush (as at concrete gutters, walks, and paving), they shall conform smoothly at all joints.
F. Ridges, indentations, and other objectionable marks left in the surface of the asphalt concrete by paving or rolling equipment shall be eliminated by rolling. The use of equipment that leaves ridges, indentations, or other objectionable marks in the asphalt concrete shall be discontinued, and other acceptable equipment shall be employed.
G. Where cold joints are indicated or necessary, cut back the placed and compacted cold asphalt a minimum of three inches with a concrete or masonry power saw, so that a vertical face of compacted full thickness material is exposed. Treat this surface with a tack coat

before proceeding with the placement of new asphaltic concrete surfacing.

H. Finish paving shall conform to finish elevations within plus or minus 0.01 of a foot and shall be level to within plus or minus 1/4 inch in 10 feet when measured with a 10 foot straightedge in any direction.

3.04 FIELD QUALITY CONTROL

A. The Contractor shall control the quality of the work and shall provide adequate testing to assure compliance with these Specifications.

B. After completion of paving work, all paving shall be flooded with water, and any resulting "ponds" shall be ringed with chalk. Such hollows shall be corrected with addition of asphalt paving materials and rerolling until all paving is completely level and free from hollows and high spots.

C. The Engineer shall perform in-place density and compaction tests of the completed pavement in accordance with California Test 375 to determine compliance with specified requirements. Test shall be performed as often as necessary to verify compliance, but not less frequently than the following:
   1. One test required.

3.05 MAINTENANCE OF PAVEMENT

A. Upon completion of final rolling, traffic shall not be permitted on the finished pavement for at least six hours, and until the asphalt concrete has cooled sufficiently to withstand traffic without being deformed. Finished pavement shall be maintained in finished clean condition until the work is accepted by UCB.

END OF SECTION

This page left intentionally blank.

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 321316

SITE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Formwork.
   2. Reinforcement.
   3. Expansion Joint Fill Material.
   4. Concrete Placement.
   5. Finishing.
   6. Curing.
   7. Detectable Tile
   8. Downspout Nozzle

B. For Earthwork, see Division 31.

C. For Irrigation, see Section 32 84 00.

D. For Site Sealants, see Section 32 13 73.

E. For Site Furnishings, see Section 32 30 00.

F. For Soil Preparation and Soil Mixes, see Section 32 91 13.

G. For Planting Area Finish Grading, see Section 32 91 19.

H. For Plant Material, see Section 32 93 00.

I. For Site Metalwork, see Section 32 94 13.

J. For Landscape Drainage, see Section 33 41 01.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance” or “accepted” are used herein, they mean acceptance of Owner’s representative in writing.

B. Finishing Tolerances:
   1. “Class A”: True plane within 1/8" in ten feet as determined by a 10-foot straightedge placed anywhere on the slab in any direction.
   2. “Class B”: True plane within 1/4" in ten feet as determined by a 10-foot straightedge placed anywhere on the slab in any direction.

1.3 REFERENCES

A. ASTM — American Society for Testing and Materials:
   1. A82/A82M — Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement. Most current edition.
   2. A 497/A497M — Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement. Most current edition.
   3. A 615/A615M — Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Most current edition.
   4. A 767/A767M — Specification for Zinc-Coated Bars for Concrete Reinforcement. Most current edition.
   5. A 775/A775M — Specification for Epoxy-Coated Reinforcing Steel Bars. Most current edition.
   6. C 33 — Specification for Concrete Aggregates. Most current edition.
   7. C 150 — Specification for Portland Cement. Most current edition.
   8. C 171 — Specification for Sheet Materials for Curing Concrete. Most current edition.
   9. C 260 — Specification for Air-Entraining Admixtures for Concrete. Most current edition.
   10. C 309 — Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Most current edition.
   11. C 494/C494M — Specification for Chemical Admixtures for Concrete. Most current edition.
   12. C 881/C881M — Specification for Epoxy-Resin Base Bonding Systems for Concrete. Most current edition.
   13. C 979 — Specification for Pigments for Integrally Colored Concrete. Most current edition.
   14. C 1116 — Specification for Fiber-Reinforced Concrete and Shotcrete. Most Current Edition.
   15. D 1751 — Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Most current edition.
   16. D 1752 — Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction. Most current edition.

B. ACI — American Concrete Institute, Manual of Concrete Practice:
   1. ACI SP66— Manual of Standard Practices for Detailing Concrete Structures. Most current edition.
   2. ACI 303R — Guide to Cast-in-Place Architectural Concrete Practice. Most current edition.
   3. ACI 304R — Recommended Practice for Measuring, Mixing and Placing Concrete. Most current edition.
   4. ACI 305R — Recommended Practice for Hot Weather Concreting. Most current edition.
   5. ACI 306R — Recommended Practice for Winter Concreting. Most current edition.
   6. ACI 308 — Standard Practice for Curing Concrete. Most current edition.
   7. ACI 318 — Building Code Requirements for Reinforced Concrete. Most current edition.
   8. ACI 347R — Recommended Practice for Concrete Formwork. Most current edition.

C. AWS — American Welding Society:
   1. B3.0 — Standard Qualification Procedure. Most current edition.
   2. D12.1 — Reinforced Concrete Construction. Most current edition.

D. CRSI — Concrete Reinforcing Steel Institute:
   1. MSP-1-90 — Manual of Standard Practice. Most current edition.

1.4 SUBMITTALS

A. Product Data:
   1. Expansion joint fill material and/or sealant as called for in the Drawings.
   2. Color admixtures.
   3. Micro-reinforcement.

B. Samples:
   1. Expansion Joint Fill Material/Sealant: Submit one 12-inch length.

C. Shop Drawings:
   1. Form board and tie hole layout for concrete retaining wall.

D. Design Data:
   1. Concrete mix.

E. Test Results:
   1. Concrete Cylinder Tests.

1.5 QUALITY ASSURANCE

A. Contractor Qualifications: Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the Work of this Section.

B. Regulatory Requirements: Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.

C. Field Samples:
   1. Provide one 6-feet by 6-feet sample of each type of concrete paving. Include the specified color admixture, finish, control joints, expansion joint materials, and edge treatments.
   2. Provide one 6-feet long staircase segment, with 3 sets of treads, of concrete steps with a wall along one side. Include the specified color admixture, finish, nosing treads, expansion joint materials, tie holes and edge treatments.
   3. Provide one 9-feet long segment of concrete planter/wall. Include a minimum of two stepped offset walls with openings for planting. Include the specified color admixture, finish, control joints, expansion joint materials, and edge treatments.
   4. Provide one 6-feet long segment of concrete retaining wall. Include the specified color admixture, control joints, expansion joint materials, tie holes and edge treatments.
   5. Provide one 6-feet long segment of concrete planter wall, a minimum of 2 courses high. Include the specified color admixture, control joints, expansion joint materials, tie holes and edge treatments.
   6. Construct as many samples as necessary to achieve an accepted finish over the entire surface of the sample.
   7. Samples which are completely or partially finished incorrectly will be rejected.
   8. Remove rejected samples immediately from the site.
   9. Place the accepted sample in a location where the finishers can easily reference the sample finish.

1.6 DELIVERY, STORAGE AND HANDLING

A. Welded Wire Fabric: Leave tags designating size and spacing on each roll until installed.

1.7 SITE CONDITIONS

A. General Environmental Requirements: Protect concrete against extreme cold and heat, frost, rapid drying and damage by rain.

B. Environmental Requirements for Dowel Epoxy: Meet requirements of manufacturer's current printed instructions.

1.8 WARRANTY

A. General Description: In addition to manufacturer's warranties, warrant Work for a period of one year from the Date of Final Completion against defects in materials and workmanship.

B. Additional Items Covered: Warranty shall also cover repair of damage to other materials and workmanship resulting from defects in materials and workmanship.

C. Exceptions: Contractor shall not be held responsible for failures due to ordinary wear, neglect by Owner, vandalism, or other causes beyond the Contractor's control.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND SUPPLIERS

A. Dowel Epoxy or Resin:
1. The Rawlplug Company, Inc. – www.rawlplug.com
2. Hilti, Inc. – www.us.hilti.com.
3. Sika Corporation – usa.sika.com.
4. Or accepted substitute.

B. Expansion Joint Material:
1. Williams Products, Inc. – williamsproducts.net.
2. Or accepted substitute.

C. Coloring Admixtures for Colored Concrete:
1. L. M. Scofield Company – www.scofield.com.
2. Or accepted substitute.

D. Form Sealer:
1. Nox-Crete – www.noxcrete.com.
2. Or accepted substitute.

E. Form Release Agent:
1. Nox-Crete – www.noxcrete.com.
2. Or accepted substitute.

2.2 MATERIALS

A. Cement for Grey Cement Concrete:
   1. ASTM C 150, Type I Portland Cement.

B. Coarse Aggregate for Grey Cement Concrete:
   1. ASTM C 33, ACI 304R.

C. Fine Aggregate for Grey Cement Concrete:
   1. ASTM C 33, ACI 304R.

D. Reinforcing Bars:
   1. ASTM A 615, grade 60, deformed billet-steel bars, clean and free from rust, scale, or coating that will reduce bond.

E. Welded Wire Fabric:
   1. ASTM A 185 plain wire, ASTM A 497 deformed wire.

F. Tie Wire:
   1. 16 gauge or heavier, black annealed wire.

G. Supports for Reinforcement:
   1. Meet requirements of CRSI-MSP-1.
   2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are stainless steel protected.

H. Dowels:
   1. Quality: ASTM A 615, smooth, billet-steel bars.
   2. Size: As shown on Drawings.

I. Water: Clean, potable, concrete mixing water free from injurious amounts of salts, oils, acids, alkalis, organic materials, iron, rust or other deleterious substances which would cause staining.

J. Air Entrainment: ASTM C 260, non-staining.

K. Coloring Admixtures for Colored Concrete: ASTM C 979, Chromix Admixture, color as indicated on Drawings, as available from L. M. Scofield Company, Los Angeles, Calif.; (213) 723-5285.

L. Expansion Joint Material: ASTM D 1752 Type II cork, or ASTM D 1752 Type I, sponge rubber with 30 to 40 pounds per cubic foot density, 95 percent minimum recovery and compatible with joint sealant to be used.

M. Form Release Agent: Non-staining material.

N. Chemical Admixtures: ASTM C 494, colored and water-reducing and/or retarding compatible, Type A or Type D, as required.

O. Admixture Restrictions for Colored Concrete: Do not use calcium chloride or other accelerating admixtures containing calcium chloride, fly ash, or any admixtures that will stain colored and white concrete.

P. Acid for Etching: Stain-proof which will not contaminate color of concrete.

Q. Curing Paper: ASTM C 171.

R. Dowel Epoxy: ASTM C 881, 2-part, chemical resistant, structural epoxy, designed for use in anchoring threaded rods, bolts, reinforcing bars, and smooth dowels to solid material.

S. Curing Compounds for Non-Colored Concrete: ASTM C 309, non-staining.

T. Dowel Sleeve: Plastic dowel cap, 4" length sized to fit dowels.

U. Concrete Planter/Retaining Walls and Stairs Forming Material:
   1. MDO or HDO composite overlaid plywood for face forms.
   2. Synthetic Polyethylene or milled wood for reveals and corner forms.

V. Form Sealer: Nox-Crete Clear Pre-Form transparent, penetrating polyurethane wood sealer.

W. Aggregate Base for on-grade Installation: Per Geotechnical Investigation Report.

2.3 MIXES

A. Architectural Concrete:
   1. Meet applicable requirements of ACI 303R for mix proportioning and mixing.
   2. Meet applicable requirements of ACI 304R for mix proportioning and mixing, except as modified by ACI 303R.
   3. Employ commercial testing laboratory to design concrete mixes with 3,000 psi minimum strength at 28 days, maximum 4 inch slump and admixtures compatible with color admixture.
   4. Submit mix design data to Owner's representative for review prior to mixing.
   5. For colored concrete elements incorporate color admixture into mix by meeting the requirements of the color admixture manufacturer's current printed instructions and do not exceed 10 percent of mix content by weight.

B. Non-Architectural Concrete:
   1. Meet requirements of ACI 304R for mix proportioning and mixing.
   2. Employ commercial testing laboratory to design concrete mixes with 3,000-psi minimum strength at 28 days, maximum 4-inch slump and admixtures compatible with color admixture.
   3. Submit mix design data to Owner's representative for review prior to mixing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.

B. Subgrade Verification: Verify that subgrade is properly compacted and installed at correct elevations.

C. Notification of Unsuitable Conditions: Before proceeding with Work, notify Owner and Owner's representative in writing of unsuitable conditions.

3.2 PREPARATION

A. Protection:
   1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant materials and walks on or adjacent to the site of the Work.
   2. Provide barricades, fences or other barriers to protect existing conditions to remain from damage during construction.
   3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
   4. Submit written notification of damaged plants and structures to Owner and Owner's representative.

B. Surface Preparation: Remove water and other materials which could be absorbed by concrete from substrate or base.

3.3 EARTHWORK

A. For Earthwork, see Division 31.

3.4 FORMWORK

A. General:
   1. Meet applicable requirements of ACI 303R.
   2. Meet applicable requirements of ACI 304R, except as modified by ACI 303R.
   3. Construct forms accurately to dimensions, plumb and true to line and grade.
   4. Use forms that are strong, mortar tight, braced and tied so as to maintain position and shape during placing of reinforcing and concrete.
   5. Wavy surfaces and bulged walls or slab surfaces resulting from settlement or springing of formwork will be rejected.
   6. Carefully verify and check forms for alignment and level as the Work proceeds.
   7. Make needed adjustments or add additional bracing prior to pouring concrete.

B. Form Materials at Exposed Surfaces:
   1. Smooth metal or MDO or HDO composite overlaid plywood for smooth finish, assembled with Class A formed finish for minimal surface deviation.
   2. Boards shall be sealed to avoid lignin-induced retardations of set of the surface fines, and resulting dusting.

C. Reveals: Reveals shall be formed with sealed synthetic materials or milled wood.

D. Tolerances:
   1. Top of form units shall not vary more than 1/8 inch from a 10-foot long straight edge placed on any orientation on any location on the surface.
   2. Vertical and horizontal surfaces shall not vary more than 1/8 inch from a 10-foot long straight edge placed on any orientation on any location on the surface.

E. Joints:
   1. Construct forms and assemble them in such a manner so that joints occur at accepted locations.

2. Provide a means to seal forms at joints such as foam tape, caulking or other gasket devices to avoid fines leaking out and rock pockets.

F. Corners:
   1. Form intersecting planes to provide true, clean-cut corners, with edge grain of plywood not exposed to face of concrete.
   2. Form exposed corners to produce square smooth, solid unbroken lines, unless indicated otherwise.

G. Coordination of Trades: After forms have been placed notify other trades in sufficient time to complete installation of their Work.

H. Other Trade Requirements:
   1. Construct chases, slots and recesses as required.
   2. Consult other trades for definite locations, sizes and shapes.
   3. Locate inserts, anchor plates and other items to be embedded in concrete where required, properly place and securely anchor.

I. Recesses and Openings: Provide as shown on the Drawings.

J. Prior to Pouring Concrete:
   1. Thoroughly clean out forms to be used.
   2. Thoroughly wet wood forms where form coatings are not used.

K. Placement:
   1. Allow zero drop to minimize entrapped air and eventual surface defects.
   2. Placement can use a tremie tube.
   3. Vibration shall be carefully done.

L. Form Ties:
   1. Ties shall be laid out in a regular pattern and per accepted Shop Drawings.
   2. Tie holes shall be partially patched per accepted Field Sample.

M. Form Member Sealing:
   1. After form boards have been placed in final form position, seal forming members and corner/reveal members.
   2. Apply in two coats, wet-on-wet, and according to manufacturer's current directions.

N. Removal of Forms:
   1. Do not remove supporting forms or shoring until concrete has sufficient strength to carry its own weight and other loads upon it.
   2. Remove forms only after concrete has properly set and without damaging concrete.

O. Re-use of Forms:
   1. Do not reuse if there is any evidence of surface wear or tear which would impair quality of finishes.
   2. Store formwork and form materials in such a manner as to prevent damage or distortion.

3. Clean forms after each use, and coat with form release agent as often as required to ensure separation from concrete without damage to concrete finish.

3.5 REINFORCEMENT

A. Fabrication and Placement: Meet applicable requirements of CRSI-MSP-1, ACI 318, ACI 303R and ACI 304R.

B. Coordination with Other Trades: Coordinate other trades' schedules to avoid disturbing or moving Work already installed by one trade to admit the Work of another.

C. Supports:
   1. Accurately and securely fasten or support reinforcements to prevent displacement before or during pouring.
   2. Hang footing bars from forms.
   3. Support wire mesh with metal cradles.

D. Reinforcement Splices:
   1. Overlap welded wire fabric one mesh minimum.
   2. Overlap reinforcing bar 24 times the bar diameter minimum, except as otherwise noted.

E. Dowel Epoxy: Meet requirements of manufacturer's current printed instructions.

3.6 CONCRETE PLACEMENT

A. Other Requirements: Meet applicable requirements of ACI 303R and ACI 304R, except as modified below.

B. Hot Weather Placement: Meet requirements of ACI 305R.

C. Cold Weather Placement: Meet requirements of ACI 306R.

3.7 FINISHES

A. Floated Finish:
   1. After the concrete has been placed, consolidated, struck off, and leveled, do not work the concrete further until ready for floating.
   2. Begin floating when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation.
   3. During or after the first floating, check the planeness of the surface with a ten foot straightedge applied at not less than two different angles.
   4. Cut down high spots and fill low spots, and produce a surface with a Class B tolerance throughout.
   5. Re-float the slab immediately to a uniform sandy texture.

B. Wood Troweled Finish:
   1. Prior to wood float troweling, provide a preliminary floated finish.
   2. Trowel initial surface relatively free from defects, with some trowel marks visible.

3. Thoroughly consolidate surface by a second troweling.
4. Provide a finished surface essentially free from trowel marks, uniform in texture and appearance, and in a plane of Class A tolerance.
5. Surface shall match the accepted field sample and be slip-resistant in compliance with ADA requirements.

C. Acid Etching Finish:
1. Prior to acid etching, provide a troweled finish on up-facing horizontal surfaces and provide a smooth form finish on vertical surfaces.
2. Perform acid etching in as continuous an operation as possible, utilizing the same work crew to provide a finish matching the accepted field sample.
3. Expose the aggregate and surrounding matrix surfaces to provide an acid-etching finish matching the accepted field sample.

3.8 CONTROL JOINTS

A. Type and Location: As detailed on the Drawings.

B. Tooled joints: Form in fresh concrete using a jointer to cut the groove so that a smooth uniform impression is obtained.

3.9 SCORE JOINTS

A. Location, Width and Radius: As detailed on the Drawings.

B. Saw-cutting: Saw-cut grooves so that a smooth uniform impression is obtained.

3.10 EXPANSION JOINT FILL MATERIAL

A. Locations and Widths: Provide joint material as shown on the Drawings, and where concrete paving abuts walls, curbs, or other structures.

B. Installation:
1. Place joint materials with top edge below the paved surface as shown on the Drawings.
2. Secure in place to prevent movement.
3. Install a rigid joint cap over the top of the fill material if required to keep top of fill material straight.

3.11 CURING

A. Other Requirements:
1. Meet requirements of the ACI 303R except as modified by requirements below.
2. Meet requirements of ACI 308, except as modified by ACI 303R and requirements below.

B. Colored Concrete: Do not use curing compounds.

C. Hot Weather Curing: Meet requirements of ACI 305R.

D. Cold Weather Curing: Meet requirements of ACI 306R.

3.12 PATCHING

A. Projections: Remove projecting fins, bolts, wire, nails, etc., not necessary for the Work, or cut them back 1 inch from the surface and patch in an inconspicuous manner.

B. Voids:
   1. Fill holes with an accepted patching material the same color as the adjoining concrete.
   2. Mix and place patching material and finish flush with the adjacent surface.

C. Corrective Patching:
   1. Correct defects in concrete Work.
   2. Chip voids to a depth of at least 1 inch with the edges perpendicular to the surface and parallel to form markings
   3. Fill voids, surface irregularities, or honey-combing by patching or rubbing.
   4. Insure that concrete surfaces so repaired duplicate the appearance of the unpatched Work.

D. Defective Work: Remove in its entirety and replace defective concrete Work which after corrective patching fails to duplicate the appearance of un-patched Work as determined by the Owner's representative and fails to meet the requirements of these Specifications.

3.13 FIELD QUALITY CONTROL

A. Test Cylinders:
   1. Provide minimum three 6-inch by 12-inch cylinders for each 150 cubic feet or 5,000 square feet of pour.
   2. Test 1 cylinder at 7 days, test second cylinder at 28 days, and test third cylinder only if needed for confirmation of compressive strength.
   3. Submit test results to Civil Engineer and Owner's representative.

B. Field Observation Reviews by Owner's representative: Coordinate and schedule with Owner's representative.

3.14 CLEANING

A. Concrete Work:
   1. The day prior to final review, remove stains, dirt and other materials using water and mild detergents.
   2. Do not use other methods of cleaning unless accepted by the Owner's representative.

3.15 PROTECTION

A. Concrete Work: Protect Work against damage and defacement during subsequent construction operations until Final Completion by installing fencing, barriers and protective coverings.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 321373

SITE SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Expansion Joint Sealant.

B. For Site Concrete, see Section 32 13 16.

C. For Site Metalwork, see Section 32 94 13.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance” or “accepted” are used herein, they mean acceptance of District’s representative in writing.

1.3 REFERENCES

A. ASTM — American Society for Testing and Materials:
   1. C 920 — Specification of Elastomeric Joint Sealants. Most current edition.
   2. C 1193 — Guide for Use of Joint Sealants. Most current edition.

1.4 SUBMITTALS

A. Product Data:
   1. Sealant.
   2. Bond Breaker.
   3. Joint Primers.
   4. Backup Material.

B. Samples:
   1. Sealant Colors.
   2. Bond Breaker.

C. Manufacturer’s Instructions:
   1. Sealant manufacturer’s current printed installation instructions.

1.5 QUALITY ASSURANCE

A. Contractor Qualifications: Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the Work of this Section.

1.6 WARRANTY

A. General Description: In addition to manufacturer's warranties, warrant Work for a period of one year from Date of Final Completion against defects in materials and workmanship.

B. Additional Items Covered: Warranty shall also cover repair of damage to other materials and workmanship resulting from defects in materials and workmanship.

C. Exceptions: Contractor shall not be held responsible for failures due to neglect by District, vandalism and other causes outside the Contractor's control.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Sealant:
   1. Pecora Corporation – http://www.pecora.com.
   2. Or approved equal.

2.2 MATERIALS

A. Sealant for Expansion Joints: ASTM C 920, Type M, Grade NS, Class 25, Use T, multi-component, cold-applied, chemically-curing, elastomeric, polyurethane joint sealant, suitable for water immersion, with a 40+ Shore A hardness.

B. Joint Primers: Use only those primers which have been tested for durability on the surfaces to be sealed and are specifically recommended for this installation by the manufacturer of the sealant used.

C. Backup Materials: Use only those backup materials which are non-absorbent, non-staining, and specifically recommended for this installation by the manufacturer of the sealant used.

D. Masking Tape: For masking around joints, provide an appropriate masking tape which will effectively prevent application of sealant on surfaces not scheduled to receive it, and which is removable without damage to substrate.

E. Bond Breakers: Use only those bond breakers which are specifically recommended by the sealant manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.

B. Joint Size Verification: Verify that the required proportion of width of joint to depth of joint has been provided.

C. Notification of Unsuitable Conditions: Before proceeding with Work, notify District and District's representative in writing of unsuitable conditions.

3.2 PREPARATION

A. Protection:
   1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, irrigation systems, plant materials and paving on or adjacent to the site of the work.
   2. Provide barricades, fences or other barriers as necessary to protect existing conditions to remain from damage during construction.
   3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
   4. Submit written notification of conditions damaged during construction to the District and District's representative immediately.

B. Preparation of Concrete Surfaces:
   1. Clean surfaces to be dry, sound, and free from dust, concrete residue and other materials which could weaken bond or conflict with sealant width and depth.
   2. At open joints, remove dust by mechanically blown compressed air if required.
   3. Remove oil and grease, use sandblasting or wire brushing.
   4. Where surfaces have been treated, remove the surface treatment by sandblasting or wire brushing.

3.3 INSTALLATION

A. Priming:
   1. Meet requirements of the manufacturer's current printed instructions.
   2. Meet requirements of ASTM C 1193, except where in conflict with manufacturer's instructions.

B. Bond-Breaker Installation:
   1. Meet requirements of the manufacturer's current printed instructions.
   2. Provide bond-breaker where recommended by the manufacturer of the sealant, and where indicated by the Drawings.

C. Backup Installation:
   1. Install back-up material where shown on the Drawings.
   2. Use a blunt-surfaced tool of wood or plastic, having shoulders designed to ride on the adjacent finished surface and a protrusion of the required dimensions to assure uniform depth of backup material below the sealant.
   3. Do not use a screwdriver or similar sharp-ended tool to install backup material.
   4. Using the blunt surfaced tool, smoothly and uniformly place the backup material to the depth required by the sealant manufacturer's current printed instructions, compressing the backup material no more than 25 percent and securing a positive fit.
   5. When using backup of tube or rod stock, avoid lengthwise stretching of the material.
   6. Do not twist or braid hose or rod backup stock.

D. Masking: Thoroughly and completely mask joints on exposed surfaces.

E. Equipment:
   1. Apply sealant under pressure with power-actuated hand gun or manually-operated hand gun, or by other appropriate means.

2. Use guns with nozzle of proper size, and providing sufficient pressure to completely fill the joints as designed.

F. Sealant Thickness: Meet requirements of the manufacturer's current printed instructions.

G. Tooling Sealant:

1. Tool sealant to insure complete filling of the joint to eliminate air pockets and voids and to insure positive adhesive of the sealant with the bonding surfaces.
2. Tool joints to the profile shown on the Drawings or if such profiles are not shown on the Drawings provide uniformly smooth joints with slightly concave surface.
3. Do not use tooling agent unless specifically recommended in writing by the manufacturer of the sealant.

3.4 FIELD QUALITY CONTROL

A. Field Observation Reviews by District's representative: Coordinate and schedule with District's representative.

3.5 CLEANING

A. Sealant Residue: Before it hardens, clean sealant from adjacent surfaces as the installation progresses, using solvent or cleaning agent recommended by the manufacturer of the sealant used.

END OF SECTION

SECTION 32 16 13

CONCRETE CURB, GUTTERS, RAMPS AND WALKWAYS

PART 1 - GENERAL

1.01 SUMMARY

the Drawings and as specified herein.

1.0

of California, Department of Transportation, Standard Specifications, latest edition.

1.0

as Product Information submittals.

PART 2 - PRODUCTS

2.0

2. Provide air-entrainment of three percent with admixture conforming to ASTM C260.
3. Nominal size of large aggregate shall be 1".
4. Minimum strength of concrete shall be 4000 psi.

PART 3 - EXECUTION

3.0

inclusive, except as modified in the plans and herein.

B. Unless shown otherwise on the Drawings, replace existing curbs and sidewalks in kind within the City of Oakland right-of-way.

C. Adjust structures such as valve boxes, manhole frames and covers, and electrical vaults to grade after the curb and gutter or sidewalk has been constructed for a reasonable distance on all sides of the structure. Complete the concrete work after the structure is adjusted.

E. New concrete sidewalk within the City of Oakland right-of-way shall have #4 rebar at 18-inches each way and shall be colored with 1-1/2 pounds of lamp black per cubic yard to match existing concrete sidewalk.

F. When installing concrete curbs, gutters, and sidewalks within the City of Oakland right-of-way the Contractor shall provide continuous access and concrete protection by whatever means necessary for the concrete until it dries. The Contractor shall replace any new concrete that is marked with graffiti before it dries at no additional cost to the Owner.

G. Control and expansion/construction joints shall be located and installed as indicated in the landscape plans.

H. Concrete finish shall be as indicated in the landscape plans.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 323000

SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fabrication of Site Furnishings.
   2. Placement of Site Furnishings.

B. For Site Metalwork, see Section 32 94 13.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance” or “accepted” are used herein, they mean acceptance of Owner’s representative in writing.

1.3 REFERENCES

A. ASTM — American Society for Testing Materials:
   1. A 185/A185M — Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement. Most current edition.
   2. A 615/A615M — Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Most current edition.
   3. C 33 — Specification for Concrete Aggregates. Most current edition.
   4. C 140 — Method of Sampling and Testing Concrete Masonry Units. Most current edition.
   5. C 150 — Specification for Portland Cement. Most current edition.
   6. C 330 / C 330M — Specification for Lightweight Aggregates for Structural Concrete. Most current edition.
   7. C 881/C881M — Specification for Epoxy-Resin-Base Bonding Systems for Concrete. Most current edition.
   8. C 979 — Specification for Pigments for Integrally Colored Concrete. Most current edition.
   9. C 1116 / C 1116M — Specification for Fiber-Reinforced Concrete. Most current edition.

B. Uniform Building Code (UBC). Most current edition.

C. Standard Grading and Dressing Rule No. 15, West Coast Lumber Inspection Bureau (SCLIB). Most current edition.

D. American Lumber Standards Committee (ALSC).

E. Product Standard 1 of the U.S. Dept. of Commerce (PS-1). Most current edition.

F. Forest Stewardship Council (FSC).

G. American Wood Preservers’ Association (APE).

1.4 SUBMITTALS

A. Samples:
   1. Steel Frame and Inserts for Site Furnishings:
   2. Trash Receptacle: 4-inch segment of finish
   3. Recycling Receptacle: 4-inch segment of finish
   4. Bicycle Rack: 4-inch segment of finish
   5. Bollard: 4-inch segment of finish
   6. Tree Grate: 12-inch segment of grate and attachment.

B. Shop Drawings:
   1. Show shop and erection details, to scale, including dimensions, sizes, thicknesses, gauges, finishes, joining, attachments, holes, welds, bolts, elevations and relationship of work to adjoining construction. Prepare details at not less than 3 inches = 1 foot.
   2. Where items must fit and coordinate with finished surfaces and/or constructed spaces, take measurements at site and not from the Drawings.
   3. Indicate welded connections using AWS A2.0 welding symbols.

C. Manufacturer's Current Printed Instructions:
   1. Furniture Manufacturer's Cleaning Instructions.

1.5 QUALITY ASSURANCE:

A. Fabricator Qualifications:
   1. Established reputation having work similar to that specified, in use for a minimum of 5 years.
   2. Shop shall have proper equipment for Work specified, including application of finish.
   3. Fabricators and finishers shall be recognized experts in the Work they are engaged to perform.

B. Regulatory Requirements:
   1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over such Work.
   2. Provide for inspections and permits required by federal, state and local authorities in furnishing, transporting, and installing materials.

C. Field Samples:
   1. Construct as many samples as necessary to achieve an accepted finish over the entire surface of the sample.
   2. Samples which are finished incorrectly will be rejected.
   3. Remove rejected samples immediately from the site.
   4. Place the accepted sample in a location where the finishers can easily reference the sample finish.
   5. The field sample may be installed and remain as part of the permanent installation if found acceptable by the Owner's representative.
   6. The field sample, when accepted, shall become the project standard for tolerances and appearance.

1.6 DELIVERY, STORAGE AND HANDLING

A. Loading and Shipment:
   1. Carefully pack the units for shipment free from stains and other deleterious material.
   2. Exercise precautions against damage in transit.

B. Storage:
   1. Store units on non-staining wood skids or pallets at least four inches above grade.
   2. Place and stack skids and units to distribute weight evenly and to prevent breakage or cracking.
   3. Protect and store units from weather and soiling with waterproof non-staining covers or enclosure, but allow air to circulate around units.

C. Handling:
   1. Handle units to prevent chipping, breakage, soiling or other damage.
   2. Do not use pinch or wrecking bars without protecting edges of units with wood or other rigid materials.
   3. Lifts with wide-belt type slings wherever possible.
   4. Do not use wire rope or ropes containing tar or other substances which might cause staining.
   5. If required, use wood rollers and provide cushion at end of wood slides.

1.7 WARRANTY

A. General Description: In addition to manufacturer's warranties, warrant Work for a period of one year from Date of Final Completion against defects in materials and workmanship.

B. Additional Items Covered: Warranty shall also cover repair of damage to other materials and workmanship resulting from defects in materials and workmanship.

C. Exceptions: Contractor shall not be held responsible for failures due to normal wear, neglect by Owner, vandalism and other causes outside the Contractor's control.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Trash and Recycling Receptacles:
   1. mmcite – www.mmcite.com.

B. Bicycle Rack:
   1. mmcite – www.mmcite.com.

C. Bollard
   1. mmcite – www.mmcite.com.

D. Tree Grate
   1. Urban Accessories – www.urbanaccessories.com

E. Detectable Warning Plate
   1. Neenah Foundry – www.nfco.com

2.2 MANUFACTURED UNITS

A. Trash and Recycling Receptacle:
   1. Type: Crystal CS211x
   2. Finish: Powder-coated Steel
   3. Color: TBD
   4. Quantity: 6

B. Bicycle Rack:
   1. Type: Lot Limit SL505
   2. Finish: Powder-coated Steel
   3. Color: TBD
   4. Quantity: 6

C. Bollard:
   1. Type: Elias SE150
   2. Finish: Powder-coated Steel
   3. Color: TBD
   4. Quantity: 15

D. Tree Grate
   1. Type: Jamison (4’ x custom)
   2. Finish: Cast Ductile Iron w/ rust conditioner
   3. Color: N/A
   4. Quantity: TBD

E. Detectable Warning Plate
   1. Type: 24” x 36” Quick Connect Plates
   2. Finish: Cast Iron
   3. Color: N/A
   4. Quantity: TBD

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.

B. Notification of Unsuitable Conditions: Before proceeding with Work, notify Owner and Owner’s representative in writing of unsuitable conditions.

3.2 PREPARATION

A. Protection:
   1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, irrigation systems, plant materials and paving on or adjacent to the site of the Work.

2. Provide barricades, fences or other barriers as necessary to protect existing conditions to remain from damage during construction.
3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
4. Submit written notification of conditions damaged during construction to the Owner and Owner's representative within 2 working days of observed damage and before damage is covered.

3.3 INSTALLATION

A. General:
1. Install as indicated on Drawings.

3.4 FIELD QUALITY CONTROL

A. Field Observation Reviews by Owner's representative: Coordinate and schedule with Owner's representative.

3.5 CLEANING

A. General: Clean and keep clean until Owner accepts maintenance.

B. Furniture Cleaning Method: Meet requirements of manufacturer's current printed instructions.

3.6 PROTECTION

A. Furniture Storage: Protect furniture from damage due to construction Work operations and vandalism by storing in secure interior storage room until day of final review.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 328400

IRRIGATION

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 DESCRIPTION OF WORK

A. Provide all products and execute all labor to achieve installation of the irrigation system complete as indicated by the Drawings and Specifications.

1.3 RELATED WORK IN OTHER SECTIONS

A. Related Landscape Work:

1. Section 32 91 19, Planting Area Finish Grading
2. Section 32 91 13, Soil Preparation and Soil Mixes
3. Section 32 93 00, Plant Material
4. Section 32 01 00, Landscape Maintenance Period

B. Other Related Work: Consult all other relevant Specification Sections to determine the extent and character of work specified elsewhere, but related to that included herein.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Laws, Codes and Regulations: Perform work in accordance with all applicable laws, codes, and regulations required by authorities having jurisdiction over such work.

B. Inspections and Permits: Provide for all inspections and permits required by federal, state and local authorities in furnishing, transporting and installing materials.

1.5 TRAFFIC CONTROL

A. It is the responsibility of the contractor to ensure adequate protection and controls for pedestrian and vehicular traffic in the vicinity of the project areas. The contractor shall provide all signs, barricades, flagmen, etc., necessary to meet all traffic requirements for this project at his own expense.

1.6 APPLICABLE STANDARDS

A. Comply with the current applicable specifications and guidelines of the following:

1. DIV — Division of Industrial Safety.
2. UPC — Uniform Plumbing Code published by the Association of Western Plumbing Officials.
3. ASTM — American Society for Testing and Materials.
4. NSF — National Sanitation Foundation.

1.7 SUBMITTALS

A. Product data: Prior to delivery to site, submit 5 copies of current manufacturer's specifications and catalog cuts for the complete list of materials and assemblies to be installed.

B. Final Record Documents: Submit Final Record Documents to the Landscape Architect at Preliminary Review.

1.8 RECORD DOCUMENTS

A. Progress Record Documents:

1. Maintain on the construction site at all times a record of all materials and equipment installed each day.
2. Daily record information neatly to scale, on full-size prints of the irrigation construction documents.
3. Record information neatly to scale, on full-size prints of the irrigation construction documents.
4. Information shall include all changes, substitutions, and manufacturer's names and catalogue members for materials and equipment. Show actual locations of all valves and irrigation piping. Show dimensions from easily-identifiable permanent structures such as walls, curbs, fences, buildings or walks.

B. Final Record Documents:

1. Transfer all information noted on Progress Record Documents.
2. After Work completion, transfer information noted on prints. Submit Progress Record Documents to the landscape architect for review of general information content (landscape architect will not be responsible for errors or omissions).
3. Contractor shall be responsible for accuracy of information and errors or omissions.
4. If first submittal is not accepted by landscape architect, resubmit until accepted.
5. Once accepted, submit accepted final Record Documents to Owner

1.9 SERVICE MANUALS

A. Submittal Procedure: At Preliminary Review, submit five individually bound Service Manuals to the Landscape Architect.

B. Content:

1. Complete drawings, diagrams and spare parts lists of all equipment installed showing components and catalog numbers together with the manufacturer's name and address.

2. Index sheet indicating the Contractor's name, address and telephone number.

3. Copies of equipment, warranties and certificates.

4. Complete operating and maintenance instructions in sufficient detail to permit operating personnel to understand, operate, and maintain all equipment.

1.10 DEFINITION OF ACCEPTANCE

A. Wherever the terms "acceptance" or "accepted" are used herein, they mean acceptance of Landscape Architect in writing.

1.11 INTENT OF DRAWING AND SPECIFICATIONS

A. It is the intent of the Drawings and Specifications to provide a complete operable irrigation system. Any items not specifically shown in the Drawings or called for in the Specifications, but which are normally required to conform with such intent, are to be considered as part of the work.

1.12 SUBSTITUTIONS

A. Written Acceptance: Specific reference to manufacturer's names and products specified in these sections are used as standards; this implies no right to substitute other materials or methods without written acceptance of the Landscape Architect.

B. Contractor's Responsibility: Installations of accepted substitution(s) must be made to the satisfaction of Landscape Architect and without additional cost to Owner.

1.13 REVIEW OF SITE

A. Visit project site and review conditions as they exist prior to submitting bid.

1.14 WORK SCHEDULE

A. Submit a proposed work schedule to the Landscape Architect for acceptance at least fourteen days prior to start of irrigation work. Submit revised schedule(s) to the Landscape Architect immediately.

1.15 COORDINATION

B. Coordinate and cooperate with other contractors to enable the work to proceed as rapidly and efficiently as possible in a workmanlike manner.

1.16 PROTECTION OF EXISTING CONDITIONS

C. General: The Contractor shall use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, irrigation systems, plant materials and paving on or adjacent to the site of the work.

D. Barriers: Provide barricades, fences or other barriers as necessary to protect existing conditions to remain from damage during construction.

E. Operations: Do not store materials or equipment, permit burning, or operate or park equipment under the drip line of existing plants to remain.

F. Notification of Damages: Submit written notification of all conditions damaged during construction to the Owner and Landscape Architect immediately.

G. Determination of Damage: Landscape Architect will determine the extent of damage and value of damaged plant material.

H. Replacement of existing plant material: Replace existing plants to remain which are damaged during construction with plants of the same species and size as those damaged at no cost to the Owner.

I. Replacement of Existing Irrigation System: Immediately repair damage to existing sytems. After making repairs remove all heads in repaired circuit(s) and flush lines clear of all dirt and foreign matter. After cleaning lines replace heads and return system to operating status.

1.17 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Labeling: Furnish standard products in unopened manufacturer's standard containers bearing original labels showing quantity, analysis and name of manufacturer.

B. Storage: Store products with protection from weather or other conditions which would damage or impair the effectiveness of the product. Protect PVC pipes and fittings from direct sunlight. Beds on which pipe is stored must be full length of pipe.

1.18 ANALYSIS OF SAMPLES AND TESTS

A. Analyses: Samples of materials may be taken and analyzed for conformity to specification at any time. The Contractor shall furnish samples as requested.

B. Rejected Materials: Contractor shall remove rejected materials immediately from the site.

C. Cost of Testing: The Contractor shall pay cost of testing of materials not meeting specifications.

1.19 HYDROSTATIC TESTING REVIEW

A. Time of Review: The Landscape Architect will review the completed irrigation work during the hydrostatic testing prior to the backfilling of the trenches.

B. Notification of Review: Notify the Landscape Architect and Owner's Representative at least 72 hours prior to the anticipated review.

1.20 PRELIMINARY ACCEPTANCE, FINAL ACCEPTANCE AND COMMENCEMENT OF THE MAINTENANCE PERIOD

A. See Section 32 01 00, Landscape Maintenance Period.

1.21 WARRANTY

A. In addition to manufacturer's guarantees or warranties, work shall be warranted for 1 year from the date of Final Acceptance against defects in material, equipment and workmanship. Warranty shall also cover repair of damage to any part of the premises resulting from leaks or other defects in materials, equipment, and workmanship to the satisfaction of the Owner.

1.22 WARRANTY FOR SPRINKLER IRRIGATION SYSTEM

A. Include the following warranty on contractor's letterhead with service manuals:

1. WE HEREBY WARRANT THAT THE SPRINKLER IRRIGATION SYSTEM WE HAVE FURNISHED AND INSTALLED IS FREE FROM DEFECTS IN MATERIALS AND WORKMANSHIP, AND THE WORK HAS BEEN COMPLETED IN ACCORDANCE WITH THE DRAWINGS AND SPECIFICATIONS. WE AGREE TO REPAIR OR REPLACE ANY DEFECTS IN MATERIAL OR WORKMANSHIP, ANY SETTLING OF BACKFILLED TRENCHES, WHICH MAY DEVELOP DURING THE PERIOD OF ONE YEAR FROM DATE OF ACCEPTANCE AND ALSO TO REPAIR OR REPLACE ANY DAMAGE CAUSED BY ANY DEFECTS IN THE IRRIGATION SYSTEM OR RESULTING FROM THE REPAIRING OR REPLACING OF SUCH DEFECTS AT NO ADDITIONAL COST TO THE OWNER. ORDINARY WEAR AND TEAR, UNUSUAL ABUSE OR NEGLECT ARE EXCEPTED. WE SHALL MAKE SUCH REPAIRS OR REPLACEMENTS, INCLUDING COMPLETE RESTORATION OF ALL DAMAGED PLANTING, PAVING, OR OTHER IMPROVEMENTS OF ANY KIND, WITHIN A REASONABLE TIME, AS DETERMINED BY THE OWNER, AFTER RECEIPT OF WRITTEN NOTICE. IN THE EVENT OF OUR FAILURE TO MAKE SUCH REPAIRS OR REPLACEMENTS WITHIN A REASONABLE TIME AFTER RECEIPT OF WRITTEN NOTICE FROM THE OWNER, WE AUTHORIZE THE OWNER TO PROCEED TO HAVE SAID REPAIRS

OR REPLACEMENTS MADE AT OUR EXPENSE AND WE WILL PAY THE COSTS AND CHARGES THEREFORE UPON DEMAND.

PROJECT: _____

LOCATION: _____

CONTRACTOR: _____

LICENSE No.: _____

TELEPHONE: _____

GUARANTEE TO: _____

_____

_____

DATE OF ACCEPTANCE: _____

AUTHORIZED REPRESENTATIVE: _____

PART 2 - PRODUCTS

2.1 PIPE

A. General: All pipe shall be NSF approved.

B. Piping on Pressure Side of Control Valves:

1. ASTM D 1785 polyvinyl chloride (PVC) 1120-1220, Class 315 for 2 inch, Schedule 40 for 1.5 inch and smaller.

C. Piping on Non-pressure Side of Control Valves:

1. ASTM D 1785 polyvinyl chloride (PVC) 1120-1220, Schedule 40.
2. Subsurface Dripline: As listed on Drawings.

2.2 FITTINGS

A. Fittings for Pressurized Solvent-Welded Pipe:

1. ASTM D 2466 Schedule 40 PVC as provided by the same manufacturer as the pipe.
2. Connections of Mains to Remote Control and Quick-coupling Valves: ASTM D 2467 Schedule 80 PVC solvent-weld socket fittings.

B. Fittings for Non-Pressurized Solvent-Welded Pipe:

1. ASTM D 2466 and ASTM D 2467 Schedule 40 and Schedule 80, polyvinyl chloride, standard weight, as manufactured by “Sloane,” “Lasco,” or accepted substitute. Refer to installation details.
2. Threaded PVC Nipples: Schedule 80 PVC.

2.3 NIPPLES

A. Non-Ferrous: Schedule 40 red brass (85% copper, 15% zinc) with MIPT at both ends; ASTM B43.

B. Plastic: Schedule 80, Type I, Grade 1 polyvinyl chloride (PVC); threaded both ends; ASTM D1784 and D1785; uniformly grey in color.

C. Flexible: Factory made and assembled consisting of flexible polyvinyl chloride (PVC) hose fitted at each end with Schedule 40 PVC male adaptors; test rated at 200 psi static.

2.4 SLEEVE FOR CONTROL WIRE AND WATER LINE

A. PVC 1120-1220, Schedule 40 pipe.

2.5 IRRIGATION CONTROLLER

A. As shown on the Drawings.

2.6 REMOTE CONTROL VALVES

A. As shown on the Drawings.

2.7 CONTROL WIRE

A. As shown on the Drawings.

B. Splicing Materials: DBR/Y-6 as manufactured by 3M.

2.8 VALVE BOXES FOR REMOTE CONTROL VALVES IN PLANTING AREAS

A. Model No.: 1419B-12B.

B. Color of Box and Lid: As shown on Drawings.

C. Manufacturer: Oldcastle Precast, Inc., 1002 15th Street SW, Auburn, WA 98001, (800) 735-5566.

2.9 VALVE BOXES FOR QUICK COUPLING VALVES IN PLANTING AREAS

A. Model No.: 910-12B.

B. Color of Box and Lid: As shown on Drawings.

C. Manufacturer: Oldcastle Precast, Inc., 1002 15th Street SW, Auburn, WA 98001, (800) 735-5566.

2.10 VALVE BOXES

A. For Remote Control Valves:

1. Planted Areas: Injection-moulded of Polyesters and fibrous inorganic temperature resistant components. Box shall provide adequate clearance to operate and service valve. Box and lid to be black, as manufactured by “Oldcastle Precast” or accepted equal.

2.11 QUICK-COUPLING VALVES

A. Valve and Key: As specified on Drawings.

B. Valve shall be as shown on the Drawings, 3/4" two-piece brass with locking cover.

C. Furnish two Rainbird No. 33-DK valve keys fitted with 3/4" swivel hose cells.

2.12 STEEL STAKES AND PIPE CLAMPS

A. As shown on Drawings.

PART 3 - EXECUTION

3.1 LAYOUT

A. General: During installation, conform as closely as possible to Drawings. Drawings are diagrammatic to the extent that swing joints, offsets and all fittings are not shown.

B. Coverage: Make any necessary minor adjustments to layout required to achieve full coverage of irrigated areas at no additional cost to Owner.

C. Stubouts: Where connections to existing stubouts are required, make necessary adjustments should stubouts be located differently than shown on the Drawings.

D. Piping: Where piping is shown to be under paved areas but running parallel and adjacent to planted area, install piping in planted areas, unless specifically noted to be installed under paved areas. Do not install directly over another line in same trench.

E. Existing Irrigation System: Adjust new head layout as necessary where it abuts existing irrigation systems.

3.2 TRENCHING

A. Trench Depths:

1. 18-inch deep over pipe on pressure side of irrigation control valve, control wires and quick-coupling valves.
2. 12-inch deep on non-pressure side of irrigation control valve.

B. Trench Slopes:

1. Mains: Slope to drain to control valves.
2. Laterals: Slope to or from control valves.

3.3 CONDUITS AND SLEEVES

A. Conduit: Furnish and install conduit where control wires pass under or through structures or paving. Conduits to be of adequate size to accommodate retrieval for repair of wiring and shall extend 12 inches beyond edges of walls.

B. Sleeving: Install sleeves for all pipes passing through or under structures or paving as shown on Drawings. Sleeving to be of adequate size to accommodate retrieval of wiring or piping for repair and shall extend 12 inches beyond edges of paving or other structures.

3.4 PIPE LINE ASSEMBLY

A. General:

1. Install pipes and fittings in accordance with manufacturer's latest printed instructions.
2. Clean all pipes and fitting of dirt, scales and moisture before assembly.
3. Install pipe fittings with at least 2 inches clearance from other pipes or fittings.

B. Solvent-Welded Joints for PVC Pipes:

1. Use solvents and methods specified by pipe manufacturer.
2. Let solvents cure a minimum of 1 hour before applying any external stress on the piping and at least 24 hours before placing the joint under water pressure.

C. Threaded Joints for Swing Joints:

1. Use Teflon tape on threaded PVC fittings for swing joints only.
2. Use strap-type friction wrench only. Do not use metal-jawed wrench.

D. Laying of Pipe:

1. Remove from trench all rocks or clods 1 inch diameter or larger. Bed pipes in at least 2 inches of soil excavated from trench. Backfill on all sides of piping to provide a uniform bearing.
2. Snake pipe from side to side of trench bottom to allow for expansion and contraction. One additional foot per 100 ft. of pipe is the minimum allowance for snaking.
3. Do not lay PVC pipe when there is water in the trench.

3.5 IRRIGATION CONTROL VALVES

A. Valve Locations: Install control valves where shown on Drawings and group together where practical.

B. Valve Box Locations: Where two or more valves are installed adjacent to each other, provide at least 12 inch separation between valve boxes and align boxes parallel to each other in a row.

C. Valve Boxes: Install valve boxes over valves to be flush with accepted finish grade.

3.6 SPRINKLER HEADS

A. Bubbler Heads: Install all bubblers per the Manufacturers current printed instructions.

3.7 QUICK COUPLING VALVES

A. Install on a swing joint assembly as detailed on the drawings.

3.8 AUTOMATIC CONTROLLER

A. Irrigation Diagram: Affix a non-fading copy of irrigation diagram to cabinet door below controller name. Irrigation diagram to be sealed between two plastic sheets 20 mil. minimum thickness. Irrigation diagram shall be a reduced copy of the Record Drawing, clearly showing all new valves operated by the controller, station number, valve size, and type of planting irrigated.

3.9 CONTROL CABLE

A. Placement: Install control wires in common trenches with sprinkler mains and laterals wherever possible. Lay to the bottom side of pipe line. Provide a minimum of 3 feet of looped slack at valves.

B. Detection Wire: Install a AWG size #12 or greater wire on top of the PVC supply line for the purpose of possible future mine detection search as the control wires are being installed on the bottom for the PVC supply line with electrical tape every 10 feet.

C. Splicing: Crimp control wire splices at remote control valves. Seal with specified splicing materials. Line splices will be allowed only on runs of more than 2,500 feet.

3.10 CLOSING OF PIPE AND FLUSHING OF LINES

A. Capping: Cap or plug all openings as soon as lines have been installed to prevent entrance of materials that would obstruct the pipe. Leave in place until removal is necessary for completion of installation.

B. Flushing: Thoroughly flush out all water lines before installing heads, valves and other hydrants.

C. Testing: Test as specified below. Upon completion of testing, complete assembly and adjust sprinkler heads for proper water distribution.

3.11 HYDROSTATIC TESTING

A. Procedure: Make hydrostatic tests with risers capped when welded PVC joints have cured at least 24 hours. Center load piping with backfill to prevent pipe from moving under pressure. All couplings and fitting shall be exposed. Apply continuous static water pressure of 125 psi as follows:

1. All Piping on the Pressure Side of Control Valves: Four hour test.

2. All Piping on the Non-pressure Side of Control Valves: Two hour test.

B. Leaks and Retest: Repair leaks observed from tests and repeat testing until system passes tests.

3.12 BACKFILLING AND COMPACTING

A. Backfill Material at Planting Areas:

1. After system is operating and required tests and reviews have been made, backfill excavations and trenches with clean sand and soil, free of debris.
2. Backfill in 6-inch lifts with compaction performed between each lift.

B. Backfill Material at Unsleeved Pipe Under Paving: Provide all PVC pipe under paving with minimum of 4 inches of sand backfill on all sides and 30 inches cover to bottom of paving.

C. Backfill Material at Existing Underground Pipes: Use only backfill material which has been screened to eliminate all material larger than 3/8 inches when backfilling adjacent to existing underground pipe lines.

D. Backfill Compaction:

1. Regardless of the type of pipe covered, compact to minimum 95% density under pavements, and 85% in planted areas.
2. Compact trenches in areas to be planted by thoroughly flooding or jetting.
3. Compact trenches in paved areas in 6-inch lifts.

E. Finish Grading: Dress off all areas to accepted finish grades. Refer to Section 32 91 19, Planting Area Finish Grading.

3.13 CLEAN-UP

A. Daily: Keep all areas of work clean, neat and orderly at all times.

B. Final: Clean up and remove all deleterious materials and debris from the entire work area prior to Final Review.

END OF SECTION

SECTION 329113

SOIL PREPARATION AND SOIL MIXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Subsoil Ripping of Planting Areas.
   2. Amendment of On-Grade Planting Area Soil.
   3. Mixing and Placement of Plant Pit Backfill Soil Mix.
   4. Mixing and Placement of Soil Mixes.

B. For Earthwork, see Division 31.

C. For Landscape Maintenance Period, see Section 32 01 00.

D. For Irrigation, see Section 32 84 00.

E. For Planting Area Finish Grading, see Section 32 91 19.

F. For Plant Material, see Section 32 93 00.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance” or “accepted” are used herein, they mean acceptance of Owner’s representative in writing.

1.3 ALLOWANCE

A. Allowance for Backfill Mixes and Soil Amendment Programs:
   1. Provide cash allowance based on materials specified assuming new materials are purchased and installed.

B. Prior to purchase of materials, after final backfill mixes and amendment programs have been accepted by Owner’s representative, submit complete documentation of labor, materials and equipment comparing allowance with proposed installed costs of final mixes and amendment program.

C. Credit unused monies to Owner.

1.4 REFERENCES

A. ASTN – ASTM International
   1. D 1557 – Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. Most current edition.

2. C 136 – Test Method for Sieve Analysis of Fine and Coarse Aggregates. Most current edition.
3. D854 – Test Method for Specific Gravity Soils. Most current edition.
4. D2974 – Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils. Most current edition.
5. D3665 - Practice for Random Sampling of Construction Materials. Most current edition.
6. D4427 – Classification of Peat Samples by Laboratory Testing. Most current edition.

B. USDA – United States Department of Agriculture:
1. Soil Texture Triangle Classification. Most current edition.
2. Handbook No. 60. Most current edition.

C. ASA – American Society of America.

D. SSSA - Soil Science of America.

E. UC – University of California.

F. Geotechnical Investigation Report: Geotechnical Investigation Report by A3GEO, dated June 10, 2013.

1.5 SUBMITTAL

A. Product Data:
1. Chemical Additives.
2. Sand.
3. Organic Compost.
4. Peat Moss.
5. Perlite.
6. Fertilizers.
7. Water Storing Polymer.
8. Planter Pot Soil.
9. Aggregate for Structural Soil Mix.

B. Test Reports:
1. Provide a “Complete Standard Analysis” of site soils, imported soils, and organic compost indicating the following:
   a. pH measurement in the Saturation Extract, Electrical Conductivity of the saturation extract and Sodium Adsorption Ration of the saturation extract. Utilize the following procedures utilizing the Methods of the United States Salinity Laboratory as published in the Agricultural Handbook Number 60 entitled “Diagnosis and Improvement of Saline and Alkali Soils”:
      (a) pH Method 21
      (b) Saturation Extract Method 2
      (c) Sodium Adsorption Ratio Method 20b
      (d) As determined by ammonium bicarbonate-DTPA: Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, Soil Science Society of America, Inc., 1986,identify the following nutrients and elements:
      (e) Boron, calcium, copper, iron, magnesium, manganese, molybdenum, phosphorous, potassium, sodium, sulfur, and zinc.

(f) Analyze the saturation extract for calcium, magnesium, sodium, boron, chloride, phosphorus, nitrate and sulfate.

b. Measure the following trace metals by the ammonium bicarbonate-DTPA extract: Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, Soil Science Society of America, Inc., 1986.
   (a) Aluminum, arsenic, cadmium, chromium, cobalt, lithium nickel, selenium, silver, strontium, tin and vanadium.

c. Determine the presence of calcium carbonate and/or magnesium carbonate.

d. As determined by Methods of Soil Analysis, Part 3 Chemical Methods, Soil Science Society of America, Inc., 1996, identify Soil Texture (gravel, sand, silt and clay) and percent gravel.

e. As determined by Methods of Soil Analysis, Part 3 Chemical Methods, Soil Science Society of America, Inc., 1996, identify organic matter content by the measurement of organic carbon. The quality of organic matter shall be determined by measuring organic carbon and total nitrogen.

f. As determined by Method 34b of Agricultural Handbook Number 60, identify Water Infiltration Rate.

g. Interpretation of nutritional deficiencies or excesses and potential toxicities shall be given.

h. Define import soil source and organic matter locations.
   (a) Provide copy of the planting plan with each composite sample keyed by number to the area from which the composite samples were taken.

i. Soil Test for Parasitic Nematodes (if required).

j. Soil Test for Herbicide Contamination (if required).

k. Samples shall include location of source material, date of samples, and project name.

l. Bulk density and particle size analysis, including the following gradient of mineral content (USDA Designation is size in mm)
   (a) Gravel – over 2mm
   (b) Sand – 0.05 – 2mm
   (c) Silt – 0.002-0.05mm
   (d) Clay – minus 0.002mm

m. Sieve Analysis performed and compared with USDA Soil Classification System. Sieve analysis shall be by a combined hydrometer and wet sieving using sodium hexametaphosphate as a dispersant in accord with particle size analysis, Chapter 15, Methods of Soil Analysis, Part 1, SSSA-ASA, Inc., 1986.

2. Structural Soil Mix Testing: Provide a two-gallon representative sample to Wallace Laboratories for an analysis of the structural soil mix indicating the following:

a. Particle size analysis, including the following gradient of mineral content (USDA Designation Size in mm):
   (a) 3” (76mm)
   (b) 2 ½” – 3” (63-76mm)
   (c) 2” – 2 ½” (50-63mm)
   (d) 1 ½” – 2” (37-50mm)
   (e) 1” (25-37mm)
   (f) ¾” (19-25mm)
   (g) Fine gravel – 1/8” – ¾” (2-19mm)
   (h) Sand – 0.05 -2mm
   (i) Silt – 0.002-0.05mm
   (j) Clay – minus 0.002mm

b. Provide manufacturer’s analysis of the following:
   (a) Loose and rodded unit weight.

(b) Bulk specific gravity and absorbance.
(c) Gravel dimension and surface texture description.
(d) Aggregate soundness and L.A. abrasion.
(e) Sample Collection Procedure:
(f) Collect a minimum of eight samples to make up the composite sample.
(g) Take samples from random locations in the stockpile varying from the top to the bottom and around the stockpile.
(h) Take at least half the samples from the lower third of the stockpile into a clean bucket
(i) Thoroughly mix material after samples are taken.
(j) Remove 2 gallon of material from bucket and fill a zip-lock plastic bag.
(k) Double bag the composite sample and label the bag with a permanent marker indicating the material name and date sample was taken.

3. Provide a percent pore space analysis as follows:
   a. 1 minus [rock specific gravity unit divided by the bulk specific gravity] times

1.6 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.
   2. Provide for inspections and permits required by federal, state and local authorities in furnishing, transporting, and installing materials.

B. Contractor Qualifications:
   1. Have successfully installed structural soil mixes similar to the quality specified for a period of not less than 5 years.
   2. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the Work of this Section.

1.7 SITE CONDITIONS

A. Environmental Requirements:
   1. Do not work soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in the air or that clods will not break readily.
   2. Apply water, if necessary, to bring soil to an optimum moisture content for tilling.
   3. Do not work soil when muddy or frozen.
   4. Do not apply chemicals if wind conditions will cause hazardous drift to people or property.

B. Existing Conditions:
   1. Prior to Work commencement review locations of existing public underground utilities and structures with appropriate utility companies and clearly mark in field.
   2. Prior to Work commencement review location of existing private underground utilities and structures with Owner and clearly mark in field.
   3. Prior to Work commencement and after reviewing the Owner's record irrigation documents, review and clearly mark in field heads, valve boxes and other underground equipment, materials and structures.

1.8 PROJECT CONDITIONS

A. Areas to receive structural soils shall be inspected by Owner's Representative before starting work.

B. Verify extent of work requirements, including but not limited to potential need for temporary storage and staging of soils, including moving soil stockpiles at site to accommodate other work and the need to protect installed soils from compaction, erosion and contamination.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND SUPPLIERS

A. Pre-Plant Fertilizer for On-Grade Planting Areas:
   1. Gro-Power, Inc. – http://www.gropower.com.
   2. Or accepted substitute.

B. Other Commercial Fertilizers:
   1. Or accepted substitute.

C. Humate:
   1. Humate International, Inc. – http://www.humateintl.com.
   2. Or accepted substitute.

D. Polymer:
   1. Complete Green Company – http://www.bettertopsoils.com.
   2. Or accepted substitute.

E. Soil Testing Agency:
   1. Wallace Laboratories – http://us.wlabs.com.
   2. Or accepted substitute.

F. Geotextile Fabric
   1. Carthage Mills – http://carthagemills.com.
   2. TenCate Nicolon Corporation – http://www.tencate.com.
   3. Or accepted substitute.

G. Structural Soil Mix:
   1. TMT Enterprises – http://www.tmtenterprises.net.
   2. Or accepted substitute.

2.2 MATERIALS

A. Soil for Backfill Mix: Soil excavated from on-site plant pits.

B. Organic Compost:
   1. Fully composted aerobic compost without presence of decomposition products.
   2. Redwood and cedar products are not acceptable.
   3. Ash content of not less than 8 percent and no more than 50 percent.
   4. pH between 6 and 7.

5. Salt content shall be less than 10 millimho / cm @ 25 degrees (ECe less than 10) in a saturated paste extract.
6. Boron content of saturated extract <1.0 parts per million.
7. Silicon content (acid-insoluble ash) shall be less than 20 percent.
8. Calcium carbonate shall not be present

C. Peat Moss:
1. Canadian Sphagnum Peat.
2. Or accepted substitute.

D. Potential Chemical Amendments Required by Accepted Amendment Programs and Backfill Mixes:
1. Ground Limestone: Agricultural limestone containing not less than 85 percent of total carbonate, ground to such fineness that 50 percent will pass No. l sieve and 90 percent will pass No. 20 sieve
2. Dolomite Lime: Agricultural grade mineral soil conditioner containing 35-percent minimum magnesium carbonate and 49-percent minimum calcium carbonate, 100 percent passing #65 sieve.
3. Gypsum: Agricultural grade product containing 80-percent minimum calcium sulfate.
4. Iron Sulfate (Ferric or Ferrous): Supplied by a commercial fertilizer supplier, containing 20- to 30-percent iron and 35- to 40-percent sulfur.
5. Potassium Sulfate: Agricultural grade (0-0-50).
6. Single Superphosphate: Commercial product (0-20-0).
7. Treble Superphosphate: Commercial product (0-48-0).
8. Ammonium Nitrate: Commercial product (30-0-0).
9. Calcium Nitrate: Agricultural grade containing 15.5-percent nitrogen.
10. Urea Formaldehyde: Granular commercial product containing 38-percent nitrogen.
11. IBDU (Iso Butyldiene Diurea): Commercial product containing 31-percent nitrogen.
12. Soil Sulfur: Agricultural grade sulfur containing a minimum of 96-percent sulfur.
13. Iron Sequestrene: Geigy Iron Sequestrene 330 Fe
14. Silicic Acid Calcium: Commercial grade.

E. Perlite:
1. Horticultural Perlite, 6.5 to 7.5 pH.
2. Or accepted substitute.

F. Volcanic Rock:
1. Clean, free of materials toxic to plant growth, 60 pounds per cubic foot (961 kilograms per cubic meter) maximum damp weight, size as specified.
2. Or accepted substitute.

G. Preplant Fertilizer for Trees, Shrubs, Ground Cover and Turf Areas:
1. Gro-Power Plus 5-3-1.
2. Or accepted substitute.

H. Polymer:
1. Soil drain / PAM.
2. Or accepted substitute.

I. Imported Loamy Sand for Landscape Fill Soils:
   1. General: Soil shall be of uniform quality and free of phytotoxic compounds.
   2. Particle Size Analysis: Less than 80-percent and more than 60-percent sand; less than 40-percent silt; less than 20-percent clay.
   3. pH: Range 5.5 – 7.5.
   4. EC: Less than 2.0 ds/m (USDA Circular No. 982).
   5. SAR: Less than 6.0.
   6. Contaminants: Free of phytotoxic compounds and debris, seeds or rhizomes of noxious weeds, herbicides, pesticides, heavy metals, biological toxins, excesses of fertilizer, component toxic to plants or humans, and less than 2-percent gravel.
   7. Salts: The electrical conductivity of the soil shall not exceed 2.-0 decisemens per meter as determined by the saturated-soil test method described in USDA Circular No. 982. The sodium absorption ratio shall not exceed 6.0. Boron levels shall not exceed 1.0 ppm.
   8. Boron: Less than 1.0 ppm.
   9. Sodium: Less than 5.0 meq/1.
   10. Chloride: Less than 5.0 meq/1.

J. Succulent Planting Soil
   1. Ultra Soil Cactus and Succulent Blend
   2. Or accepted substitute.

2.3 MIXES

A. Composition of Plant Pit Backfill Mix for Plants at Existing Site Soils for Bidding Only:
   1. Content:
      a. 6 parts by volume existing soil removed from excavated plant pit.
      b. 4 parts by volume organic compost.
      c. 2 pounds gypsum per cubic yard of mix.
      d. 1 pound ureaform (38-0-0) per cubic yard of mix.
      e. 1 pound humate per cubic yard of mix.
      f. 1/3 pound of potassium sulfate (0-0-50) per cubic yard of mix.
      g. ½-pound dry polymer per cubic yard of mix.
      h. 1/3 pound of single superphosphate (0-20-0) per cubic yard of mix.
   2. Mixing:
      a. Mix materials uniformly in bulk at one area.
      b. Mix in clean area or machine, free of materials which will contaminate mix.
      c. Do not mix materials at each pit.

B. Plant Pit Backfill Mix for Actual Installation: The accepted backfill mix based on the soil fertility test report.

C. Imported Sand/Peat Soil Mix:
   1. Content:
      a. 80% by volume #20 medium sized clean sand.
      b. 20% by volume medium sized peat similar to sand size, pH 4.0 to 6.5, ECe less than 3 millimho/cm, carbon:nitrogen ratio less than 25, minus 10 mesh, minimum cation exchange capacity is 50 millimoles per 100 grams, minimum 60% organic matter.
      c. Adjust the ratio of sand and peat to achieve the desired level of soil organic matter.
      d. 1/3 pound ureaform (38-0-0) per cubic yard of mix.
      e. 1/2 pound of potassium sulfate (0-0-50) per cubic yard of mix.

f. 1/3 pound of triple superphosphate (0-45-0) per cubic yard of mix.
g. 1/2 pound of agricultural gypsum
h. Ground agricultural limestone (calcium carbonate) – amount as needed to adjust the acidity to achieve a final pH between 6.5 and 7.2

2. Properties: Properties of mix shall be as follows:
a. Organic carbon – 2.0 to 3.5% by dry weight
b. Ammonium bicarbonate available DTPA nutrients
c. Potassium – 125 to 250 parts per million
d. Phosphorus – 25 to 40 parts per million
e. If the level of micronutrients are low, incorporate compost at 5% by volume and provide 2.5% to 4.0% organic carbon on a dry weight basis.

3. Contaminants: Free of phytotoxic compounds and debris, seeds or rhizomes of noxious weeds, herbicides, pesticides, heavy metals, biological toxins, excesses of fertilizer, component toxic to plants or humans, and less than 2-percent gravel.

4. Mixing:
a. Mix materials uniformly in bulk at one area.
b. Mix in clean area or machine, free of materials which will contaminate mix.

D. Structural Soil Mix
1. Content:
a. 4 parts structural soil aggregate.
b. 1 part soil, treated with polymer.

2. Mixing:
a. Mix polymer (PAM) with soil 48 hours ahead of blending with aggregate to allow for proper bonding.
b. Cure polymer treated soil by allowing the soil to partially dry.
c. Based upon accepted mix design, blend materials off-site in a clean area using an experienced blending operator.
d. Uniformly blend materials so that they are even distributed throughout mixtures.
e. Maintain adequate soil moisture content during mixing process.
f. Soils and mix components shall easily shred and break down without clumping.
g. Soil clods shall easily break down into a medium crumbly texture material.
h. Do not blend materials that are saturated or contain excessive water.
i. Measure and monitor amount of soils moisture at mixing site periodically during mixing process.
j. Protect materials and mixtures from contamination prior to, during, and after mixing operations.
k. Store mixes in stockpiles prior to shipment to site in clean areas protected from contamination from other materials.
l. Reblend the mix if the components have separated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.

B. Underground Utilities and Structures: Verify that the locations of utilities, structures and other underground items have been clearly marked.

C. Notification of Unsuitable Conditions: Before proceeding with Work, notify Owner and Owner's representative in writing of unsuitable conditions and conflicts.

3.2 PREPARATION

A. Protection of Existing Conditions:
   1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant materials and walks on or adjacent to the site of the Work.
   2. Provide barricades, fences or other barriers to protect existing conditions to remain from damage during construction
   3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
   4. Submit written notification of damaged plants and structures to Owner and Owner's representative immediately.

B. Surface Preparation:
   1. Inspect soil surface for sticks, oils, chemicals, plaster, concrete, and other deleterious materials.
   2. Do Work required to remove and dispose of the deleterious materials.

3.3 SOIL TESTS TO DETERMINE AMENDMENT PROGRAM

A. Take two 1-pound composite samples from 2 depths for each 2,500 square feet of planting area to be amended.

B. Collect small portions of soil from a 4-inch depth and 24-inch depth at 5 evenly scattered locations within each 2,500 square feet of planting area to form the 2 composite samples.

C. Keep the soil from each depth separate.

D. For each 2,500 square feet area mix the soil from 4-inch depth to form the 1 composite sample and mix the soil from the 24-inch depth to form the other composite sample.

E. Number samples and key numbers to a reproducible copy of the planting plan outlining each 2,500 square feet area that each pair of composite samples represent.

F. Provide samples to Wallace Laboratories for "Complete Standard Analysis" report and amendment recommendations.

G. At least 30 days prior to backfill mix or amendment Work, submit written "Complete Standard Analysis" report, including amendment recommendations, to Owner's representative for determination of the final backfill mixes and amendment program.

3.4 SOIL TESTS FOR NEMATODES AND HERBICIDE

A. Parasitic Nematodes:
   1. Test soils which have been used for agricultural purposes within the prior 12 months for parasitic nematodes.

2. Soil will be acceptable if the parasitic nematode population is less than 200 per 50 cubic centimeters of soil.
3. Do not artificially dry soil prior to testing.
4. Submit written test report to the Owner and Owner's representative.

B. Herbicide Contamination:
1. Perform a radish/rye grass growth trial on soils suspected of herbicide contamination.
2. Submit written test report to the Owner's representative.

3.5 AMENDMENT OF TURF AND GROUND COVER SOIL

A. Ripping of Compacted Areas Outside of Existing Tree Drip Lines: Where soil compaction has occurred, cross-rip to a depth of 12 inches prior to incorporating amendment

B. Cultivation of Planting Areas Outside of Existing Tree Drip Lines: Rototill planting areas to a depth of 6 inches immediately prior to incorporating amendment.

C. Cultivation Within Existing Tree Drip Lines:
1. Carefully hand cultivate within the drip lines of existing trees to remain.
2. Do not exceed 2 inches with depth of cultivation.

D. Application Rates for bidding Purposes Only
1. 6-cubic-yards nitrogen-treated pine bark per 1,000 square feet.
2. 200 pounds pre-plant fertilizer per 1,000 square feet.
3. 10 pounds iron sulfate per 1,000 square feet.

E. Application Rates for actual Amendment Work: Apply appropriate amendments to the respective soil types at the rates recommended by the accepted amendment program based on the soil fertility test report.

F. Incorporation of Amendments Outside Existing Tree Drip Lines: Incorporate uniformly within top 6 inches of soil layer with a rototiller, or other accepted method.

G. Incorporation of Amendments Inside Existing Tree Drip Lines: Incorporate uniformly into upper 2 inches of soil with hand rake or manually operated garden cultivator, or other accepted method.

3.6 BACKFILL MIX INSTALLATION

A. Scarification:
1. Immediately prior to backfill mix placement, drill 2-inch diameter by 12-inch long holes at 18 inches on center in bottom and side soil surfaces of plant pits, no closer than 12 inches to finish grade.
2. Do not drill through paving, curbs, or other structures or utilities.

B. Placement: Place mix carefully into pits avoiding damage or contamination of other Work.

C. Settlement Allowance: Place backfill mix to depth and elevation which allows for settlement.

D. Mock-Up: Mock-up areas of backfill mix at the specified depths and apply irrigation to induce settlement, if required to help determine the amount of settlement which will be caused by irrigation and rain.

3.7 IMPORT PEAT/SAND SOIL MIX INSTALLATION

A. Placement: Place mix carefully into pits or planters avoiding damage or contamination of other Work.

B. Settlement Allowance: Place backfill mix to depth and elevation which allows for settlement.

C. Mock-Up: Mock-up areas of backfill mix at the specified depths and apply irrigation to induce settlement, if required to help determine the amount of settlement which will be caused by irrigation and rain.

3.8 STRUCTURAL SOIL MIX INSTALLATION

A. Place mix carefully to avoid damage or displacement of other materials such as paving, drain rock, geotextile fabric and irrigation piping.

B. Do not mix subgrade soils on construction materials with mix.

C. Remove soil mix contaminated with subgrade soil, construction materials or debris.

D. Maintain mix in a moist, but not saturated, condition to prevent segregation of mix during placement.

E. Install mix in 6 inch lifts in locations indicated on the Drawings.

F. Compact lifts to 95 percent compaction in compliance with Geotechnical Investigation Report. Schedule the Geotechnical Engineer to perform nuclear density field tests after each lift of mix to confirm compaction.

G. Install final lift of mix to elevations indicated on the Drawings.

3.9 FIELD QUALITY CONTROL

A. Quality Control for Imported Loamy Sand Fill:
   1. Soil Test to Verify Soil Fertility and Texture:
      a. Take representative samples from at least 5 locations at the source.
      b. Provide samples to Wallace Laboratories for “Complete Standard Analysis” report and amendment recommendations.
      c. At least 30 days prior to delivery, submit written “Complete Standard Analysis” report, including amendment recommendations to Owner’s representative for verification of fertility and texture.

B. Quality Control for Amended Soils and Soil Mixes:
   1. Have Wallace Laboratories take samples and perform soil tests to verify conformance of each soil mix composition with the Specifications.
   2. Have Wallace Laboratories determine the location(s) of samples to be taken.
   3. Have Wallace Laboratories take samples for testing of the first batch mixed and take samples at 25 cubic yard intervals thereafter.
   4. Submit for review and acceptance “Complete Standard Analysis” and corrective Work recommendations if required to meet requirements of the Specifications.

5. If corrective Work is recommended by Wallace Laboratories perform the corrective Work before the commencement of backfill mix placement.
6. After the corrective Work is complete, re-test soil mix(es) and submit the analysis and recommendations for acceptance.
7. Perform the corrective Work followed by testing, and submittal of test analysis and recommendations until Wallace Laboratories indicates that the soil mix(es) meets the requirements of the Specifications.
8. When the soil test indicates that the soil mix(es) meets the requirements of the Specifications the Contractor will receive written notification of acceptance from the Owner's representative.
9. Upon receipt of written notification, the Contractor may commence with placement of backfill mix.

C. Field Observation Reviews by Owner's representative: Coordinate and schedule with Owner's representative.

END OF SECTION

SECTION 329119

PLANTING AREA FINISH GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Finish grading of planting area surfaces.

B. For Earthwork, see Division 31.

C. For Landscape Maintenance Period, see Section 32 01 00.

D. For Irrigation, see Section 32 84 00.

E. For Soil Preparation and Soil Mixes, see Section 32 91 13.

F. For Plant Material, see Section 32 93 00.

1.2 DEFINITIONS

A. Soil Subgrade: The soil surface on which topsoil is placed.

B. Finished Grades: The required final soil surface grade elevations indicated on the Drawings.

C. Aesthetic Acceptance of Grades: Acceptance by the Owner's representative in writing of the aesthetic correctness of the contours. Aesthetic acceptance does not address whether an area drains properly, whether the areas are at the correct elevations, or whether it has been compacted properly.

D. Acceptance: Wherever the terms "acceptance," "accepted," or "acceptable" are used herein, they mean acceptance of Owner's representative in writing.

1.3 REFERENCES

A. ASTM — American Society for Testing Materials:
   1. D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. Most current edition.

B. Geotechnical Investigation Report: Geotechnical Investigation Report by A3GEO, dated June 10, 2013

1.4 QUALITY ASSURANCE

A. Finish Grade Smoothness Mockup:
   1. Prepare a 20-foot by 20-foot area of finish graded soil representing the finished graded surface of the planting areas.

2. Locate mockup on site in a proposed planting area easily referenced by workers performing finish grading operations.
3. Protect accepted mockup from physical damage and erosion with fencing, canopies, sandbags or other accepted means until Final Completion.
4. The accepted mock-up shall be the standard by which finish grading is judged.

1.5 SITE CONDITIONS

A. Environmental Requirements:
1. Do not work soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in the air or that clods will not break readily.
2. Apply water, if necessary, to bring soil to an optimum moisture content for grading.
3. Do not work soil when muddy or frozen.
4. Existing Conditions:
5. Prior to Work commencement review and clearly mark in field horizontal and vertical locations of existing public underground utilities and structures with respective utility companies.
6. Prior to Work commencement review and clearly mark in field horizontal and vertical locations of existing private underground utilities and structures with Owner.
7. Prior to Work commencement and after reviewing the Owner's record irrigation documents, review with Owner and clearly mark in field locations of field heads, valve boxes, and other underground equipment, materials and structures.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: Examine site and verify that conditions are suitable for finish grading Work, and that no defects or errors are present which would interfere with or cause incorrect finish grading Work to occur.

B. Excessive Compaction: Verify that the upper 18 inches of soil is compacted no more than 70 percent as determined by ASTM D 1557.

C. Soil Preparation: Verify that subsoil ripping and soil preparation Work is complete.

D. Notification of Unsuitable Conditions: Before proceeding with Work, notify Owner and Owner's representative in writing of unsuitable conditions and conflicts.

3.2 PREPARATION

A. Protection of Existing Conditions:
1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, irrigation systems, plant materials and paving on or adjacent to the site of the Work.

2. Provide barricades, fences or other barriers to protect existing conditions to remain from damage during construction.
3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
4. Submit written notification of conditions damaged during construction to the Owner and Owner's representative immediately.

3.3 FIELD ENGINEERING

A. General:
1. Establish lines and levels, locate and lay out by instrumentation and similar appropriate means for planting area finish grades.
2. Provide grade stakes and string lines to achieve smooth finish grades with positive surface drainage.

B. Hand Graded and Screeded Areas:
1. Install grade stakes at maximum 10 feet on center each way.
2. Install additional grade stakes if required to achieve smooth, positive draining surface acceptable to the Owner's representative.

C. Machine Graded Areas:
1. Install grade stakes at maximum 25 feet on center each way.
2. Install additional grade stakes if required to achieve smooth, positive draining surface acceptable to the Owner's representative.

D. High Points and Low Points: Provide grade stakes at high points and low points including top of berms, catch basin rims and area drain rims.

3.4 FINISH GRADING OPERATIONS

A. General:
1. Grade soil surface with smooth uniform slope between points where elevations are given, and between points where elevations are given and existing grades.
2. Slope finish grades to drain surface water away from buildings, walks, paving, and other structures unless indicated otherwise.
3. Slope finish grades to drain surface water to catch basins, area drains or trench drains as shown on the Drawings.
4. Grade soil surface smooth to be free of high and low areas which will inhibit surface drainage.

B. Excessive Compaction:
1. Take precautions to prevent soil from becoming compacted more than 70 percent as determined by ASTM D 1557.
2. Rip to an 18 inch depth and rototill areas compacted more than 70 percent.

C. Screeding of Special Lawn Turf Areas:
1. After soil amendment Work has been completed, screed soil surface of planting areas smooth with straight edges.
2. Apply a minimum 1-inch of irrigation water to induce settlement and melt clods.
3. Prior to planting Work, screed soil surface smooth, adding amended soil to low areas.

D. Equipment: Use equipment of appropriate size and type to achieve the sculptural forms, profiles and smooth soil surface free of high areas, depressions and equipment tracks.

E. Depressions and Loose Material: Fill and compact any depressions, and remove loose material to finish surface true to line and grade, presenting a smooth, compacted, and unyielding surface.

3.5 TOLERANCES

A. Hand Graded Areas:
   1. Grade to within 0.03 foot of grades indicated on the Drawings, except bring soil edge surface grades, paving, curbs, and other structures to within 0.01 foot of grades shown on the Drawings.
   2. Transition soil edge surface grades along paving, curbs, and other structures to areas of less strict tolerance over 5 feet distance.

B. Machine Graded Areas: Grade to within 0.05 foot of grades indicated on the Drawings.

C. Allowances: Make proper allowances for settlement, spoils from plant pits, and addition of soil amendment.

3.6 FIELD QUALITY CONTROL

A. Aesthetic Acceptance of Grades:
   1. Upon completion of finish grading Work, schedule with Owner's representative a review to obtain aesthetic acceptance.
   2. Provide three-days advance written notification.
   3. Do not commence sodding, seeding or other planting Work until receiving aesthetic acceptance.

A. Field Observation Reviews by Owner's representative: Coordinate and schedule with Owner's representative.

END OF SECTION

SECTION 329300

PLANT MATERIAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Backfill Mixes.
   2. Drain Rock.
   3. Fertilizers.
   4. Plant Materials.
   5. Rock Mulch.
   6. Root Barriers.
   7. Root Ball Anchors.
   8. Wood Chip Mulch.

B. For Earthwork, see Division 31.

C. For Landscape Maintenance Period, see Section 32 01 00.

D. For Irrigation, see Section 32 84 00.

E. For Planting Soil Preparation, see Section 32 91 13.

F. For Planting Area Finish Grading, see Section 32 91 19.

G. For Landscape Drainage, see Section 33 41 01.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance”, “accepted”, or “acceptable” are used herein, they mean acceptance of Owner’s representative in writing, unless indicated otherwise.

B. Tie Height: Lowest Height at which tree trunk will snap back to upright position when pulled to one side and released.

C. Plant Height: Measurement of main body height, not measurement to top branch tip.

D. Plant Spread: Measurement of main body diameter, not measurement from branch tip to tip.

E. Caliper: Trunk diameter measured at a point 6 inches (150 mm) above natural ground surface for trees up to 4 inches (100 mm) in caliper, and measured at a point 12 inches (300 mm) above natural ground surface for trees over 4 inches (100 mm) in caliper.

1.3 REFERENCES

A. ANSI — American National Standards Institute:
   1. Z60.1 — American Standard for Nursery Stock. Most current edition.

B. ICBN — International Code of Botanical Nomenclature. Most current edition.

C. ICNCP — International Code of Nomenclature of Cultivated Plant. Most current edition.

D. NAAPS — National Arborist Association Pruning Standards. Most current edition.

E. UCDAS — University of California Division of Agricultural Sciences.
   1. Leaflet 2576 — Staking Landscape Trees. Most current edition.

1.4 SUBMITTALS

A. Product Data:
   1. Fertilizer Tablets.
   2. Geotextile Fabric.
   3. Root Barriers.
   4. Tree Stakes.
   5. Tree Tie.
   6. Wetting Agent and Soil Penetrant.
   7. Root Ball Anchors

B. Samples:
   1. Auxiliary Stake — 6-inch length.
   2. Cross-tie — 6-inch length.
   3. Rock Mulch — 1/2 pound bag.
   4. Wood Mulch — 1/2 pound bag.

C. Plant Material Photographs:
   1. At least 14 days prior to submittal of plant material location data, submit three color photographs each of representative plants of each type of plant material.
   2. Include a scale object in each photograph such as a tape measure or person.

D. Plant Material Location Data:
   1. Quantities and sizes of each plant material type at each nursery or other place of growth.
   2. Address, phone number, and contact person for each nursery or other place of growth.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.
   2. Provide for inspections and permits required by federal, state and local authorities in furnishing, transporting, and installing materials.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Handling Plants:
   1. Do not lift or handle container plants by tops, stems or trunks.
   2. Do not bind or handle plants with wire or rope.
   3. Pad trunk and branches where hoisting cables or straps contact.

B. Anti-Desiccant:
   1. Spray plant material in full leaf immediately before transporting with anti-desiccant.
   2. Meet requirements of anti-desiccant manufacturer's current printed application instructions.

C. Digging Plants: Dig ball and burlap plants with firm, natural balls of earth of diameter meeting or exceeding requirements of ANSI Z60.1 and of sufficient depth as required to include the fibrous and feeding roots.

D. Plant Storage Prior to Installation:
   1. Protect plant root balls from sun and drying winds.
   2. Keep root balls moist.
   3. Keep sun-sensitive plants shaded.
   4. Anchor plants to prevent damage from strong winds.

1.7 SITE CONDITIONS

A. Environmental Requirements:
   1. Protect plant material being stored on site from sun and drying winds.

B. Existing Conditions:
   1. Prior to Work commencement, review and clearly mark in field horizontal and vertical locations of public existing underground utilities and structures with respective utility companies.
   2. Prior to Work commencement, review and clearly mark in field horizontal and vertical locations of private underground utilities and structures with Owner.

1.8 WARRANTY

A. Warranty Period: Warrant that plant material, except annuals, will be healthy and in vigorous, flourishing condition of active growth one year from date of Final Completion.

B. Annuals: Warrant that annuals will be in a vigorous, flourishing condition of active growth until end of last annual change season.

C. Delays: Delays in completion of planting operations which extend the planting into more than one planting season shall extend the Warranty Period correspondingly.

D. Condition of Plants: Plants shall be free of dead or dying branches and branch tips, with foliage of a normal density, size and color.

E. Incorrect Materials:
   1. During Warranty Period, replace at no cost to Owner, plants revealed as being untrue to name.
   2. Provide replacements of a size and quality to match the planted materials at the time the mistake is discovered.

F. Replacements:
   1. As soon as weather conditions permit, replace, without cost to Owner, dead plants and plants not in a vigorous, thriving condition, as determined by the Owner's representative during and at the end of Warranty Period.

2. Apply requirements of this Section to replacements.

G. Exceptions: Contractor shall not be held responsible for failures due to neglect by Owner, vandalism and other causes outside the Contractor's control.

1.9 MAINTENANCE

A. For Landscape Maintenance Period, see Section 32 01 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fertilizer Tablets:
1. Gro Power, Inc. – www.gropower.com.
2. Grow Better – www.growbetter.com.
3. Agri Tab Corporation – www.agritab.com.
4. Or accepted substitute.

B. Anti-Desiccant:
1. Aquatrols Corporation – www.aquatrols.com.
2. Or accepted substitute.

C. Stress Reducing Agent: (DM – we need more manufacturers)
1. EarthWorks – www.soilfirst.com.
2. Or accepted substitute.

D. Wetting Agent and Soil Penetrant:
1. Aquatrols – www.aquatrols.com.
2. Harell's – www.harrells.com.
3. Or accepted substitute.

E. Drain Rock
1. American Soils Products, www.americansoil.com
2. Or accepted substitute.

F. Wood Chip Mulch:
1. Lyngso – www.lyngsogarden.com
2. American Soil Products – www.americansoil.com.
3. Or accepted substitute.

G. Rock Mulch:
1. Lyngso – www.lyngsogarden.com
2. American Soil Products – www.americansoil.com.

H. Deep Root / Aeration System:
1. Rootwell, Union Lake, MI., (888) 766-8935.
2. Or accepted substitute.

I. Geotextile Fabric:
   1. Carthage Mills – www.carthagemills.com.
   2. Mirafi – www.tcmirafi.com.
   3. Or accepted substitute.

J. Root Barriers:
   1. Deep Root – www.deeproot.com.
   2. Century Products – www.centuryrootbarrier.com.
   3. Or accepted substitute.

K. Root Ball Anchors
   1. Platipus Earth Anchoring Systems – www.platipus-anchors.com.
   2. Or accepted substitute.

2.2 SUBSTITUTIONS

A. Plant Material: Accepted substitute plants shall be true to species and variety and shall meet requirements of this Section except that plants larger than specified may be used if accepted.

2.3 MATERIALS

A. Plants:
   1. Growing Practices: Nursery grown in accordance with best horticultural industry practices.
   2. Nomenclature: Plant nomenclature shall meet requirements of ICBN and ICNCP.
   3. Climatic Growing Conditions: Grown under climatic conditions similar to those of project for at least two years unless otherwise accepted.
   4. Container Growth Limitations: Container stock excluding annuals shall have been grown in the containers in which delivered for at least six months, but not over two years.
   5. Root Ball Size: Meet or exceed requirements of ANSI Z60.1.
   6. Branching: Structurally strong, able to stand upright without stakes or guys on a windless day; exceptionally heavy, symmetrical, tightly knit, so trained or favored in development and appearance as to be superior in form, number of branches, compactness and symmetry.
   7. Vigor: Sound, healthy and vigorous, well branched and densely foliated when in leaf.
   8. Disease and Pests: Free of disease, insect pests, eggs, or larvae.
   9. Root System: Healthy well-developed root systems, free of kinked, circling, girdling and center roots, root-bound condition and cracked or broken root balls.
   10. Measurements: Measure plants when branches are in their normal upright position.
   11. Pruning: Do not prune, thin or shape plants before delivery without acceptance.
   12. Unacceptable Conditions: Multiple leaders, unless specified, damaged or crooked leaders, bark abrasions, sun-scalds, disfiguring knots, or fresh cuts of limbs over 3/4-inch diameter which have not completely callused.

B. Fertilizer Tablets:
   1. Grow-Power 21 gram tablets, 20-10-5 (N-P-K) formula.
   2. Grow-Power 7 gram ADS tablets, 12-8-8 (N-P-K) formula.
   3. Agri Tab Aquatic fertilizer, 12-20-8 in compressed spike form.
   4. Agri Tab Aquatic fertilizer, 20-5-10 5 gram tablets.
   5. Or accepted substitute.

C. Water: Clean, fresh and potable.

D. Drain Rock: ¾ inch round or acceptable substitute.

E. Wood Chip Mulch:
   1. Match existing
   2. Or accepted substitute.

F. Rock Mulch:
   1. 3/8” crushed black basalt.

G. Anti-Desiccant: Commercially available spray protective coating, designed to reduce plant transpiration loss, which produces a moisture retarding barrier not removable by rain or snow.

H. Stress Reducing Agent:
   1. Roots Concentrate.
   2. Or accepted substitute.

I. Wetting Agent and Soil Penetrant:
   1. AquaGro 2000M.
   2. AquaGro 2000G.
   3. Or accepted substitute.

J. Geotextile Fabric:
   1. Mirafi Filterweave 140 NC non-woven geotextile composed of polypropylene fibers.
   2. Carthage FX-300MF
   3. Or accepted substitute.

K. Root Barrier
   1. UB 24-2
   2. Deep Root, www.deeproot.com
   3. Or accepted substitute.

L. Root Ball Anchoring
   1. Platipus Earth Anchoring Systems, www.platipus-anchors.com.
   2. Duckbill Model 68-RBK for trees up to 3 inches caliper.
   3. Model 88 RBK for trees of 3 to 6 inches caliper.
   4. Or accepted substitute.

2.4 MIXES

A. For Plant Pit Backfill, see Section 02920.

2.5 SOURCE QUALITY CONTROL

A. Plant Material Review and Tagging:
   1. Trees will be reviewed, photographed and tagged by the Owner’s representative at the nursery, or other place of growth prior to delivery of trees to site.

2. At Owner's representative's discretion, shrubs may or may not be reviewed, photographed, and tagged by the Owner's representative at the nursery or other place of growth.
3. Tagging of plant material at the nursery or place of growth does not cancel the right of the Owner's representative to reject plant material at the site, if damage or unacceptable conditions are found that were not detected at the nursery, place of growth or in the submitted photographs.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.

B. Fine Grading and Soil Preparation: Verify that fine grading and soil preparation Work is complete.

C. Verification Surface Drainage: Verify positive surface drainage of planted areas.

D. Notification: Before proceeding with Work, notify Owner and Owner's representative in writing of unsuitable conditions.

3.2 PREPARATION

A. Protection of Existing Conditions:
1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant materials and walks on or adjacent to the site of the Work.
2. Provide barricades, fences or other barriers to protect existing conditions to remain from damage during construction.
3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
4. Submit written notification of damaged plants and structures to Owner and Owner's representative immediately.

3.3 SUBSURFACE OBSTRUCTIONS

A. Plant Pit Excavation: If rock, underground utilities, structures, tree roots or other obstructions are encountered in the excavation of plant pits, alternate locations may be accepted by the Owner's representative.

B. Cost for Removal of Obstructions: Where locations cannot be changed, submit cost estimate for Work to remove the obstructions to a depth of not less than 6 inches below the required pit depth, and proceed with Work after Owner's approval.

C. Irrigation Piping: Reroute around the plant root ball.

3.4 PLANT LAYOUT

A. Trees:

1. Stake location of trees where indicated on Drawings.
2. Scale tree locations where no dimensions are given.
3. Drive a 3-feet long wood lath stake at each tree location and mark each tree type with different color survey tape.
4. Contact Owner's representative to review locations in field prior to excavating plant pits.
5. Do not excavate plant pits until Owner's representative has accepted locations.

B. Shrubs and Groundcover.
1. Layout according to Drawings.
2. Contact Owner's representative if there are any conflicts that would prevent plants from being laid out according to Drawings.
3. Contact Owner's representative to determine if a review of locations in field, prior to excavating plant pits, is required.

3.5 EXCAVATION OF PLANT PITS

A. Equipment:
1. Excavate pits with a back-hoe or hand digging.
2. Do not use an auger.

B. Dimensions:
1. Excavate plant pits to a depth equal to the root ball height minus the amount needed to account for settlement and to install the root balls at the specified elevation relative to adjacent finished grade.
2. Install top of plant root balls 1-inch above adjacent finished grade except where indicated otherwise.
3. Excavate pits to a diameter which is 3 times the root ball diameter, except where indicated otherwise on the Drawings.
4. Center plant pits on plant locations where possible.
5. Where plant pits cannot be excavated to specified dimensions nor centered on plants due to obstructions such as paving, walls, curbs, or other structures excavate pits in directions without obstructions until pit volume equals the specified plant pit volume, except where indicated otherwise.
6. Do not undercut adjacent obstructions unless accepted by the Owner's representative.
7. Excavate plant pit sides along adjacent elements such as paving, walls, curbs, and other structures at a 45 degree angle sloping away from the bottom surfaces of the adjacent elements, except where indicated otherwise.

3.6 ROOT BARRIERS INSTALLATION

A. Locations: Install root barriers where shown on Drawings and according to manufacturer's current printed instructions.

3.7 TREE SUBDRAINAGE INSTALLATION

A. Install according to the Drawings.

B. Refer to Landscape Drainage, Section 33 41 00.

3.8 PLANTING AND BACKFILL OPERATIONS

A. Protection of Plants Prior to Installation:
   1. Protect plant root balls from sun or drying winds.
   2. Keep root balls of plants that cannot be planted immediately upon delivery in the shade, well-protected and well-watered.

B. Removal of Containers:
   1. Remove canned stock carefully after cans have been cut on two sides with accepted cutter.
   2. Do not use spade to cut containers.

C. Root Ball Scarification:
   1. After removing plant from container, scarify side of root ball to prevent root-bound condition.
   2. Loosen root ball soil surface to depth of 1/8 to 1/4 inch without damaging roots or breaking root ball.
   3.

D. Cutting Circling Roots:
   1. If circling roots are encountered at root ball sides, notify Owner's representative for field review.
   2. Upon Owner's representative's acceptance, cut roots on 4 sides of root ball 90 degrees apart at no extra cost to Owner.
   3. Use a 4-inch wide sharp straight blade.
   4. Cut roots by pushing spade or knife down sides of root ball 90 degrees to root ball surface and 2 inches into root ball.
   5. Keep spade or knife sharp to cut roots cleanly.

E. Plant Placement:
   1. Handling plant carefully, set plant root ball on pit bottom centered on accepted horizontal location.
   2. Install plant root ball vertically so that top of root ball is 1 inch above adjacent finished grade after settlement except where indicated otherwise.

F. Removal of Root ball Wrapping Materials: Remove and dispose of burlap, nylon cord, wire baskets, twine and other materials prior to backfilling.

G. Backfill Mix Placement:
   1. Place mix carefully as not to damage the plant root ball, trunk, branches, or foliage.
   2. Fill pit until top of backfill mix is even with top of root ball.
   3. Settle mix by watering evenly.
   4. Fill settled backfill mix with additional soil mix as required to bring it even with top of root ball.
   5. Continue filling and watering settled areas until settlement stops.

H. Settled Plant Adjustment: Raise plant root balls which settle so that top of root balls are at the specified elevation relative to adjacent finished grade.

I. Final Compaction: Compact soil mix by saturating with water.

J. Fertilizer Tablets:

1. Place maximum quantities recommended by the manufacturer's current printed instructions.
2. Place tablets between bottom of root ball and 1/3 way up root ball, 2 inches away from root ball.
3. Do not place tablets higher than 1/3 way up root ball.
4. Space tablets equally around root ball.
5. Install tablets at trees, shrubs, ground cover, ornamental grasses, and ferns.

K. Stress Reducing Agent:
1. After backfilling plant pits, drench backfill at rates recommended by manufacturer.
2. Drench backfill same day backfill is placed.

L. Wetting Agent and Soil Penetrant:
1. After backfilling plant pits, drench backfill at rates recommended by manufacturer.
2. Drench backfill same day backfill is placed.

3.9 ROOT BALL ANCHOR INSTALLATION

A. Manufacturer's Requirements: Meet requirements of manufacturer's current printed instructions.

B. Root Ball Characteristics:
1. Install anchors only on firm root balls.
2. Do not install anchors on trees grown in sand, sawdust or other loose growing mixes.

3.10 WOOD CHIP MULCH INSTALLATION

A. Depth: Install geotextile fabric and rock mulch at depths and locations shown on the Drawings.

B. Surface: Rake mulch surface smooth.

C. Woody Plant Stems: Slope mulch away from woody plant stems so that mulch does not touch stems.

3.11 ROCK MULCH INSTALLATION

A. Depth: Install geotextile fabric and rock mulch at depths and locations shown on the Drawings.

B. Surface: Rake mulch surface smooth.

C. Woody Plant Stems: Slope mulch away from woody plant stems so that mulch does not touch stems.

3.12 FIELD QUALITY CONTROL

A. Field Observation Reviews by Owner's representative: Coordinate and schedule with Owner's representative.

3.13 SCHEDULES

A.

A. Root Ball Anchor Schedule:

Tree Caliper at 12 Inches Above Grade	*No. of Guys*	*Cable Size*	*Turn-buckle Size*	*Ground Anchors*
3 - 6 inches	3	1/8 inch 7 × 7	1/4 × 4 inches	4 × 4 × 24 × 18 inches deep deadmen (or) Laconia LA-4-40 SM (or) Duckbill 68
6 - 8 inches	3	3/16 inch 7 × 7	5/16 × 4-1/2 inches	6 × 6 × 30 × 30 inches deep deadmen (or) Laconia LA-6-60 (or) Duckbill 88

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 33 10 00

WATER UTILITIES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. See Appendix A: Drawings for typical details. Fittings shall conform to type and pressure rating of piping in which they are used. The design and installation of UCB Campus water mains that are dedicated for the supply of fire protection systems shall comply with Appendix D: Fire Service Main Specifications. The design and installation of UCB Campus water mains that supply both fire protection systems and domestic water systems shall comply with both this section and Appendix D: Fire Service Main Specifications.
B. Path of Travel for debris removal shall meet requirements listed in Section 01 50 00 Temporary Construction Facilities

1.2 RELATED SECTIONS

A. Section 31 23 33 – Trenching and Backfilling

1.3 REFERENCES

A. Codes and Standards: The design and installation of underground water piping shall conform to the following codes and standards except as specifically noted in these standards.
   1. Latest edition of the California Plumbing Code (CPC)
   2. Latest edition of the California Fire Code
   3. Latest edition of the California Building Code
   4. Latest adopted edition of the National Fire Protection Association (NFPA) 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances
   5. American Water Work Association (AWWA) standards and manuals as appropriate for installation and materials including, but not limited to:
      a. C-104 (2013): Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
      b. C-105 (2010): Polyethylene Encasement for Ductile-Iron Pipe Systems
      c. C-150 (2008): Thickness Design of Ductile-Iron Pipe
      d. C-151 (2009): Ductile-Iron Pipe, Centrifugally Cast for Water
      e. C-503 (2014): Wet-Barrel Fire Hydrants
      f. C-504 (2010): Rubber-Seated Butterfly Valves
      g. C-600 (2010): Installation of Ductile-Iron Water Mains and Their Appurtenances
      h. C-605 (2013): Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for water
      i. C-651 (2014): Disinfecting Water Mains
      j. C-900 (2007): Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in. (100 mm Through 300 mm), for Water Transmission and Distribution
      k. M-11 (2004): A Guide for Steel Pipe Design and Installation, 4th Ed.
      l. M-14 (2014): Recommended Practice for Backflow Prevention & Cross-Connection Control, 4th Ed.
      m. M-17 (2006): Installation, Field Testing and Maintenance of Fire Hydrants, 4th Ed.
      n. M-23 (2002): PVC Pipe - Design and Installation, 2nd Ed.
      o. M-27 (2013): External Corrosion: Introduction to Chemistry and Control, 2nd Ed.
      p. M-41 (2009): Ductile-Iron Pipe and Fittings, 3rd Ed.
      q. M-55 (2006): PE Pipe—Design and Installation, 2nd Ed.

1.4 SUBMITTALS

A. Shop Drawings, Product Data, and Samples
B. Manufacturer's product data for manufactured materials and equipment, including all valves and fire hydrants.
C. Shop drawings showing all piping layout and pipe sizes, valves, hydrants, and locations of tie-ins, buttresses, and thrust blocks.
D. Manufacturer's product data for manufactured materials and equipment, including all valves and fire hydrants.

1.5 SITE CONDITIONS

A. Excavations in which products will be buried shall be dry.
B. Coordinate the installation of water supply system with the jurisdictional water utility owner.
C. Existing Underground Piping: Existing utilities and piping, where known, are shown on the Drawings. Exact locations and depths of existing lines must be determined in the field by the Contractor by exploration using methods which will not damage any existing improvements.
D. Location and Alignment of New Work: Pipe alignments may be varied from those shown on the Drawings when field conditions indicate that the change would be advantageous. Any such proposed changes shall be brought to the attention of the Engineer. Changes shall not be made until written approval from Engineer has been obtained. Provide traffic cover plates over trenches at streets, parking areas and pedestrian pathways to maintain access, unless closure is permitted by the Engineer.
E. Interference with Normal Operations at the Site: All pipe work shall be coordinated with the required excavation and backfill so that there will be a minimum of interruption in the normal use of roads, parking areas, pathways and other existing facilities.
F. Shutdowns of Existing Systems: To the extent required for the installation of the new work, shutdowns of the existing facilities will be permitted. Perform Work that involves tie-in to existing systems at such times as will cause the least inconvenience to University activities. This may be at night and/or on weekends. Prior to any shutdown, Contractor shall notify Engineer in writing at least 10 days prior to the planned tie-in. The Engineer will then schedule the shutdown with campus facilities Service staff who will determine the actual time of the tie-in as close as possible to the Contractor's request. Include in Contractor's bid the cost of overtime necessary to perform the Work. No extra payment will be allowed for overtime to meet this requirement.
G. At least one week prior to the shutdown the Contractor shall submit to the Engineer a schedule and plan showing the following: a) how connections to existing facilities are to be made; b) length of time required to accomplish the work and to get the systems into service, and c) a list of all equipment and materials required to make the tie-in. The shutdown will not be permitted to commence until the Contractor has received written permission from the Engineer and the Contractor has provided assurance to the Engineer that all necessary material, equipment and manpower will be available at the proper time so that the shutdown will proceed on schedule.

PART 2 - PRODUCTS

1.1 Valves and Cocks

A. Water: 250 lbs minimum AWWA standard, Pratt butterfly valve or equal with ends to suit pipe used. When below grade, delete hand wheel and install operating nut and valve box.
B. Install traffic rated concrete valve boxes (e.g.: G-5 Christy) and extensions to grade. Cover shall have type of service (water, gas, etc.) cast in.
C. Provide one tee handle operating wrench for each size operating nut, with length to suit maximum valve depth. See Appendix, Typical Water Service and Piping Systems, for PVC

details for extension stem.

1.2 PIPE MATERIALS, SIZES AND OTHER REQUIREMNTS

A. All piping is to be either:
   1. PVC AWWA C-900 DR-14 (Class 200); or
   2. HDPE, if specifically approved by Facilities Services and the Designated Campus Fire Marshal; or
   3. Cement-lined ductile-iron pipe (DIP) may be used only in underground fire service mains supplying building fire protection systems, which shall use cement-lined ductile-iron pipe from five feet (5'-0") outside of the foundation wall through the foundation wall to the inside of the building and be fitted with a Link Seal (or equal) device to prevent transfer of water through the wall.
   4. Water lateral shall be ASTM B88 type "K" copper pipe with brazed joints using minimum 15 % silver brazing alloy. At interior installations, pipe 3 inches and smaller shall be ASTM B88 type "L" copper pipe with lead-free solder joints.

B. Couplings and pipe thread adapters for copper tubing shall be Mueller 110 compression connection series. Soldered joints are not allowed.

C. All ferrous materials, restrainers, T-Head bolts, clamps, joint restraint clams, washers, tie rods, bolts and nuts shall have at least one coat of protective coating (bituminous mastic) of an approved type before backfilling.

D. All restrainers and ductile-iron fittings shall be wrapped with at least one layer of 10-mil plastic.

E. All ductile-iron pipe shall be wrapped with at least one layer of 10-mil plastic.

F. Hot tapping and use of saddles are not permitted unless approved in advance by the Campus Building Official.

G. Refer to the latest edition of the California Building Code. Materials and systems must be based on a comprehensive review of the project design requirements. Use of non-standard materials requires the express written consent of the Campus Building Official during the design phase of any project.

1.3 Valves

A. Valves shall conform to AWWA C-504. Valves shall be Pratt Butterfly Valves (or equivalent) except as required by section (5) (below).

B. Indicating posts used for underground valves or wall indicating valves shall be of the type that use the words "OPEN" when the valve is open and "SHUT" when the valve is closed. Mueller gate valves with a resilient seal (or equivalent) shall be used.

C. MJ Valves are not permitted to be installed on twelve-inch (12") PVC pipe.

D. Valves shall open when turned counter-clockwise.

E. The pressure ratings for all valves shall be as follows: Table 1 Pressure Zone Hydrostatic Test Pressure (PSI) Rated Working Pressure (PSI) High 200 or 50 psi + max static pressure 250 Medium 200 250 Low 200 250

F. A concrete pad shall be placed under all valves.

1.4 Water Supply Backflow Preventer Assemblies

Adhere to State requirements (California Code of Regulations Title 17: Group 4) and adopts the standards. The proper design, selection, installation and maintenance of cross-connection control devices is imperative, particularly in a university/mixed-use environment, for the protection of potable drinking water and distribution systems. Appropriate backflow prevention assemblies shall be selected from the most current USC-FCCCHR List of Approved Backflow Prevention Assemblies and shall be inspected and periodically tested as specified by the manufacturer by a certified tester.

Provide backflow protection at any building water system where there are connections, actual or

potential, to a contaminating liquid. Examples include laboratory hose cocks and connections from domestic system to HHW makeup and cooling towers.

Backflow shall be prevented by installing a backflow prevention device at each individual point of possible contamination, where devices such as vacuum breakers or air gaps may be employed, or at a single point where an industrial water piping system takes off from the domestic water piping. Industrial water used in labs for experiments is assumed to be non-contaminated. The industrial system must be protected from heating hot water, cooling towers, etc., by additional pressurereducing devices.

Select the type of backflow prevention system appropriate to each individual case. Generally, a separate industrial water system will be justified in buildings having numerous outlets that are susceptible to contamination. A chemistry or laboratory building is a good candidate for a separate industrial system.

Discuss the requirements for backflow prevention for any building located off-campus with Construction & Design (C&D) and the utility company.

A. Backflow Prevention Devices
    1. See Appendix A: Drawings for typical details.
    2. Backflow preventers shall be as indicated in the plans.
    3. A four inch (4”) outlet with bolted flange shall be provided downstream of the backflow preventer for testing purposes.
    4. All test openings in the backflow preventer shall be plugged.
    5. Bollards shall be provided where the fire hydrant, fire department connection or backflow preventer is subject to vehicular damage, as determined by the Designated Campus Fire Marshal or Facilities Services. Bollards shall comply with CFC Section 312.
    6. Select appropriate backflow prevention devices for the intended service. The following devices are listed in approximate decreasing order of effectiveness and reliability.
    7. Air-Gap Separations (a physical break between the supply pipe and a receiving vessel): The air gap shall be at least twice the diameter of the supply pipe, measured vertically above the overflow rim of the vessel with a minimum clearance of one inch (1"). This provides the maximum degree of protection and should be used wherever a non-pressurized supply is acceptable. It shall be used where sewage or toxic substances are involved.
    8. Reduced-Pressure Backflow Preventers: Use for protection of all direct or indirect connections where the device may be subject to back pressure and for isolating industrial water systems from the domestic water system. Locate in an accessible location. Where spillage is unacceptable, discharge with an air gap into a floor drain. Install backflow preventer at least 12" above floor or ground. Test cocks must be accessible.
    9. Pressure-Type Vacuum Breaker: Use only as protection for direct or indirect water connections to all types of polluted or contaminated liquids where the vacuum breakers are not subject to back pressures. These units may be installed under continuous line pressure. Install in an accessible location. Where spilling into room is objectionable, it shall be specified as modified with drain connection and waste.
    10. Anti-Siphon Ballcocks: Use for tank-type water closets and urinals. The outlet of the backflow preventer shall be at least one inch (1") above the opening of the overflow pipe.
    11. Vacuum Breakers for Flush Valves: Occurs at toilets or urinals. Specify installation at least four inches (4") above the overflow rim.
    12. Double Check Valve Assemblies: Use to protect direct or indirect water connections where contaminants entering the system would not constitute a health hazard. Examples include steam, air, foods and beverages.

PART 3 - EXECUTION

3.1 GENERAL

A. After demands are determined, size water lines on the basis of friction loss. Do not exceed ten percent (10%) of the initial pressure at full demand or 7.5 feet per second velocity with a minimum pressure of 60 psi for building services.
B. Show valves at all services from mains and at other points to minimize disruption of building operations. Valves should be located at the building exterior and where mains enter the building.
C. Use separate cold water services for domestic and fire where it is from the University system.
D. Use two pressure zones where the pressure at the lowest point of use will exceed 80 psi to maintain 35 psi at the highest point of use.
E. Thrust blocks shall be as indicated in the plans
F. Fire protection service from single building service (campus).
    1. Fire Sprinklers
        a. Provide separate service from exterior mains for buildings served by the utility company (off campus).
        b. The University will arrange for and pay for domestic and fire protection water service to off-campus buildings served by the utility company. Furnish size and pressure requirements to Construction & Design (C&D).

3.2 MAINTAINING WATER SERVICES

A. Maintain water service and conduct operations at times selected to minimize duration and inconvenience of service interruption.
B. Water valves in service owned by the jurisdictional water utility Owner shall be operated only by personnel of that jurisdictional water utility district.
C. Except as specified otherwise herein, and where applicable, materials and construction methods shall be in accordance with the provisions of the jurisdictional water utility district standard drawings and specifications.

3.3 INSTALLATION

A. Installation Requirements
    1. Excavating and backfilling, including bedding and compacting requirements, to the backflow preventer assemblies shall be in accordance with the provisions of the jurisdictional water utility district standard drawings and specifications. Excavating and backfilling, including bedding and compacting requirements, beyond the backflow preventer assemblies shall conform to Section 31 23 33 - Trenching and Backfilling.
    2. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances of buried piping. Thrust blocks shall be constructed as indicated.
    3. Install piping true to line and grade, supported and guided to assure alignment under all conditions.
    4. Install unions at each connection to valves.
    5. Make change in line with fittings. Do not spring joints to effect change of direction.
    6. Do not field cut pipe unless necessary. Make such necessary cuts by means of equipment designed for the purpose, ensuring a smooth square end.
    7. For connection to existing pipe, provide pipe with suitable ends or adapters, after verification of size and type of existing pipe.

B. Valves
    1. Install valves in accordance with the valve manufacturer’s installation instructions.
    2. Where valves are provided by the jurisdictional water utility, provide suitable access for

operation of valves.

3. If directed by Engineer, alter typical valve manhole to suit actual conditions. Any alterations in valve manholes shall be operable from the street level. All operator nuts shall be plumb to the valve manholes.Only properly authorize.
4. Unless approved by the Engineer, campus personnel shall operate, open, or close any valve in the existing system.

C. Fire Hydrants
1. Provide fire hydrant installations as indicated. Hydrants shall be installed in accordance with NFPA 24. Valves, valve boxes and hydrants shall be set plumb and boxes shall be centered over valves. All foreign matter shall be removed from the interior of hydrants and valves before installation. Hydrants and valves shall be inspected in the open and closed positions. Hydrants shall be painted as directed by the Engineer.
2. Provide necessary cathodic protection and appurtenances and accessories as required to complete the installation.

D. Thrust Blocks and Harnessing
1. Provide for counteracting thrust caused by static and dynamic forces, including water hammer at bends, tees, reducers, valves, and dead-ends by installing harnessing as indicated or required. For other methods, submit details for approval of the Engineer prior to use.
2. Provide concrete thrust blocks as indicated where harnessing is not practicable.

E. Water Service Connectors
1. Make water service connections, as indicated, in accordance with California Plumbing Code and the installation instructions of the service pipe and fittings manufacturer.

F. Acceptance Requirements
1. After installation of pipes, ends of pipes shall be either capped or plugged. No piping shall be buried before being inspected and tested.

G. Corrosion Protection

All buried ferrous metal fittings and appurtenances shall be provided with bituminous coating corrosion protection and as indicated in the design plans.

1. Ferrous metal fittings and appurtenance as herein referred to are: valves, tees, elbows, reducers, crosses, plug assemblies, pumping tees, services, blowoff installations, flexible couplings, leak clamps, tie rods, etc.
2. Joints, fittings, and appurtenances that are required to be coated by the Contractor may be coated before or after installation in the trench.
3. Cast-iron pipe or bare metal pipe extending into the soil from a concrete structure shall be insulated from the concrete and leak-proofed. The insulation shall extend through the concrete a minimum of three (3) inches on each side. The insulation shall consist of one layer of Scotchrap Tape No. 50 and two coats of bituminous paint. The pipe shall be clean, dry, and free from loose scale before applying the adhesive and tape. The edges of the tape shall be lapped not less than one-half (1/2) inch.
4. Bituminous coating shall be applied in two coats with a minimum 20-mil dry thickness per coat. Applications shall be in accordance with manufacturer's instructions. Allow first coat to dry as recommended by the manufacturer before application of second coat. Allow second coat to dry before encasing in polyethylene tubing or wrap. Inspector must inspect coating prior to covering with polyethylene. Joints must be not be covered with polyethylene during the pressure test witnessed by the Owner’s Representative.

3.4 TESTS

A. Protection from Flooding

Provide positive measures to protect exposed, installed pipe and compacted pipe bedding from flooding during testing.

B. Notice of Testing
1. Give three (3) days notice of intention of testing to the Engineer and jurisdictional agency. The Contractor will furnish, install, and operate pumps, gages, meters, and

individual pipe connections to test openings.
2. Designate largest sections feasible for testing and sterilizing.

C. Testing Requirements
1. Prior to backfilling, isolate system by use of approved valves, caps and plugs, or other means.
2. Maintain such isolation throughout the performance of leakage and pressure testing.
3. 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.
4. For hydrostatic tests, provide approved caps and plugs in sections to be tested and remove them after testing.
5. Prevent leakage in pipes and fittings at openings. Temporarily block plugged and capped ends to prevent displacement.
6. Install water source connection for testing, as directed.
7. Provide labor and materials required for leakage testing, including excavation for installation and removal of pumps, gages, meters, and water source connections.
8. Where leakage exceeds the Owner's standards, perform necessary corrective measures.
9. Remove and replace defective pipes, joints, fittings, valves and appurtenances. Reset such items if displaced.

D. Hydrostatic Tests
1. Perform hydrostatic tests in accordance with the Owner's requirements. All such tests shall be witnessed by the representative. The Contractor shall be responsible for making all such arrangements.
2. Test the fire water system hydrostatically in sections to a pressure of at least 200 psi for not less than 120 minutes. Test the domestic water system for building service lateral(s) at 60 psi for 120 minutes. Pressure test pipe before backfilling. Repair leaks and retest the system until the system is leak free. Use instruments calibrated by a quality laboratory. Test sequence shall be as follows:
   a. Lines shall be fully flushed.
   b. Lines shall be hydrostatically tested.
   c. Lines shall be fully flushed.
   d. Lines shall be fully disinfected.

3.5 SYSTEM DISINFECTION

A. Standard Disinfection Procedure For Domestic Water System
1. Supervision and Testing: Perform entire disinfection procedure under the supervision of Environment, Health and Safety (EH&S). Provide five (5) days' notice to schedule procedure.
2. Contractor's Responsibility: Furnish a copy of the California Department of Pesticide Regulation (DPR) Qualified Applicator License, equipment, materials and transportation to disinfect domestic hot and cold water systems and fire lines directly connected thereto, in conformity with procedures and standards described herein.
3. Disinfecting Agent: An aqueous solution of sodium hypochlorite (minimum 5.25% available chlorine). The use of powdered hypochlorite and chlorine gas are prohibited unless specifically approved by Environment, Health and Safety (EH&S).
4. Preliminary Preparations:
   a. Service Cock: Provide within three feet (3'-0") of the entrance of the supply main to the building, a three-quarter inch (3/4") service cock, or valve, for the purpose of introducing the disinfecting agent.
   b. Flushing: After final pressure tests and before draining for disinfection, open each fixture or outlet until the water flow is clear.
5. Disinfection Procedure:
   a. Drain entire domestic water system including fire line.
   b. Post suitable warning signs at each outlet: Warning - Do Not Use - Water System

Being Chlorinated.

c. Inject disinfectant solution into the system through the service cock by means of a pump, or other pressure device, at a slow continuous rate, simultaneous with a reduced flow from the water main, until the Ortho-Tolidin test for residual chlorine at each outlet shows a concentration of at least 50 ppm, but note more than 100 ppm.
d. Close all outlets and valves, including the service valve at the main and the injection cock. Retain the chlorinated water in the system for 24 hours.
e. After the 24 hour holding period, the residual chlorine concentration shall be not less than 50 ppm as shown by the Ortho-Tolidin test.
f. Drain and flush entire domestic water system until Ortho-Tolidin tests show background residual chlorine concentration at any and all outlets.
g. Environment, Health and Safety (EH&S) shall determine whether samples of water must be collected and analyzed for the determination of bacteriological quality.

6. Standards Necessary for Approval:
   a. The water system shall have been uniformly chlorinated under the supervision of Environment, Health and Safety (EH&S) as outlined above.
   b. The results of water sample analysis shall be negative for the Coliform organisms.
   c. If the test for the bacteriological quality of the water in the system does not meet the standards, repeat the disinfection procedure until the specified standards are met.
   d. Final Approval: Environment, Health and Safety (EH&S) shall give written approval to the University for acceptance and use of the water system after the above procedures have been successfully completed and the standards met.

3.6 CONNECTIONS TO EXISTING MAINS

A. Following testing and sterilization, new water distribution lines shall be connected to the existing main as indicated. The connection shall be made at a time and in a manner which will result in the least interruption of service.
B. All connections involving shut down of jurisdictional water utility's existing facilities shall be made under the immediate supervision of the jurisdictional water utility district. No member of the Contractor's forces may operate any valve controlling the flow of water in the water utility's existing system.
C. The Contractor shall make tie-ins to the existing system at a time which is convenient to jurisdictional water utility district, which may be in the evenings and on weekends.
D. All piping to be abandoned, as shown on the plans, is abandoned only when the pipe has been taken out of service, physically disconnected from the active water system, and has been sealed by the Contractor.
E. The Contractor shall seal all cut ends of the existing piping that are not connected to the new system by either installing temporary fittings on the existing pipe or by plugging the cut end with concrete extending two pipe diameters into the pipe. After the concrete placement, the pipe end shall be blocked with a two-inch thick redwood block.

END OF SECTION

SECTION 33 30 00

SITE SANITARY SEWERAGE SYSTEM

PART 1 - GENERAL

1.0

and install all solid wall pipe as indicated in the Drawings; and all appurtenant work, complete and operable, including all manholes, cleanouts, fittings and connections as shown on the Drawings and as specified herein.

B. Piping under existing pavement and retaining walls may be installed by jacking, boring or by hydraulic driving except as otherwise indicated in Drawings or directed. Use existing sleeves where applicable. At location where cutting is required make all cuts clean using power saws. Replace and restore all surfaces to original conditions, including grades and landscaping. Match restoration work with original work in every respect, including type, strength, texture and finish.

1.0

1.0

ASTM A 48	Specification for Gray Iron Castings.
ASTM C 150	Specification for Portland Cement.
ASTM C 478	Specification for Precast Reinforced Concrete Manhole Sections.
ASTM D 1784	Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds.
ASTM D 2241	Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR-Series).
ASTM D 3034	Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
ASTM D 3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F 477	Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

1.0

and materials proposed to be used under this Section.

alignment of sewer service and elevations along with the details associated with the improvements, location of boring pits.

1.0

the requirements of the referenced standards as applicable.

crushing tests. The crushing tests shall be made on samples taken from the center of full-length sections of pipe.

1.0

District or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify the ENGINEER no fewer than eleven (11) working days in advance of the proposed interruption of service.
2. Do not proceed with interruption of service without ENGINEER'S written permission.
3. Submit plans to the ENGINEER showing rerouting of the temporary sanitary sewer service and obtain written approval from ENGINEER prior to proceeding with the work.

PART 2 - PRODUCTS

2.0

appropriate ASTM.

B. The CONTRACTOR shall also require the manufacturer to mark the date of extrusion on the pipe.
C. Pipe shall be of the pipe pressure class as shown on the Drawings.

2.02 PIPE

shown on the Drawings:

1. PVC gravity sewer pipe shall be made from a compound conforming to a cell classification of 454 as defined by ASTM D1784 and in accordance with ASTM D3034 for sizes four inch through fifteen inch and ASTM F679 for sizes eighteen inch through twenty-four inch. The size of pipe shall be as designated on the plans and the size indicated shall be the internal clear diameter of the pipe. Individual pipe lengths shall not exceed twenty (20) feet in length.
   The wall thickness, when tested according to ASTM D3412, shall correspond to a dimension ratio of SDR26 with a pipe stiffness of 115 for heavy wall pipe. Integral bells shall incorporate locked in gaskets meeting the requirements of ASTM D3212 and F477.
2. Flexible rubber rings for elastomeric gasket joints for PVC pipe and fittings shall conform to the requirements of ASTM D 1869.
3. Sanitary Sewer pipes that are deeper than 16' shall be C900-07 (DR14). Sanitary Sewer pipes which are less than 16' deep may be C900-07 (DR 18).
4. Sanitary sewer pipes shall be green colored. If not manufactured green, sanitary sewer pipes shall be wrapped with Christy ™ TA-33-PW21, 2" x thick green 10mil polywrap, or approved equal.
5. All sanitary sewer pipe shall be joined by integral bell manufactured compression joints with elastomeric seals, which meet the requirements of ASTM D 3212 and ASTM F 477. Joints for PVC C900 sanitary sewer pipes shall be Multi Fittings® Trench Tough CIOD Sewer Fittings for C900, or approved equal. Joints for SDR sanitary sewer pipes shall be GPK® PVC Heavy Wall Sewer Fittings, or approved equal.

2.03 FITTINGS

the requirements of ASTM D 2241. The ring groove and gasket ring shall be compatible with PVC pipe ends.

pipe.

2.04 BEDDING MATERIAL

requirements for bedding in Section 31 23 24 “Trench Excavation and Backfill”.

2.05 FLEXIBLE COUPLINGS

with ASTM C 425 and provided with 2 stainless steel band screw-clamps to secure the coupling tightly to entering and exiting pipes. All screw-clamp hardware shall be Type 304 or Type 316 stainless steel. Rubber material shall be suitable for use on sewage systems. Sanitary sewer connection at the building point of connections shall be made by using Calder Couplings or approved equal.

2.06 LATERAL CONNECTIONS TO SANITARY SEWER

sewer pipe is laid.

B. Service lateral connections to existing sewers shall be made by "Tap-Tite" method, or with approved "Sealtite" type saddle fittings which utilize neoprene gasket seals and stainless steel bands.

PART 3 - EXECUTION

3.0

the ENGINEER, and shall be subject to its approval before acceptance. All material found during the progress to have defects will be rejected and the CONTRACTOR shall promptly remove such defective materials from the site of the WORK.

3.02 TRENCHING AND BACKFILL

“Trench Excavation and Backfill” and as specified herein.

3.03 PIPE LAYING

specified herein and as shown on the Drawings. The pipe sections shall be closely jointed to form a smooth flow line. Immediately before placing each section of pipe in final position for connecting joints, the bedding for the pipe shall be checked for firmness and uniformity of surface.

B. Proper implements, tools, and facilities as recommended by the pipe manufacturer's printed instructions shall be provided and used by the CONTRACTOR for safe and efficient execution of the work. All pipe, fittings, and accessories shall be carefully lowered into the trench by means of derrick, ropes, or other suitable equipment in such a manner as to prevent damage to pipe and fittings. Under no circumstances shall pipe or accessories be dropped or dumped into the trench.

C. Cutting and machining of the pipe shall be accomplished in accordance with the pipe manufacturer's standard procedures for this operation. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, nor any other method that may fracture the pipe or will produce ragged, uneven edges.
D. Installation of pipes in prepared trenches shall start at the lowest point, with the spigot ends pointing in the direction of flow.
E. The pipe and accessories shall be inspected for defects prior to lowering into the trench. Any defective, damaged or unsound pipe shall be repaired or replaced. All foreign matter or dirt shall be removed from the interior of the pipe before lowering into position in the trench. Pipe shall be kept clean during and after laying. All openings in the pipe line shall be closed with water tight expandable type sewer plugs or PVC test plugs at the end of each day's operation or whenever the pipe openings are left unattended. The use of burlap, wood, or other similar temporary plugs will not be permitted.
F. Adequate protection and maintenance of all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of the work shall be furnished by the CONTRACTOR at its own expense.
G. Installation of Warning Tape shall be THOR ENTERPRISES, CALPICO, or equal. Tape to hold the wire in place shall be pipe wrap tape, 2 inches wide, 10 mil.

3.04 PIPE HANDLING

A. Handling of all pipe shall be done with care to insure that the pipe is not damaged in any manner during storage, transit, loading, unloading, and installation.
B. Pipe shall be inspected both prior to and after installation in the trench and all defective lengths shall be rejected and immediately removed from the working area.

3.05 PVC FIELD JOINTING

A. Each pipe elastomeric-gasket joint shall be installed in conformance with the manufacturer's printed recommendations. Elastomeric Gaskets shall be conform to ASTM D3212.
B. The ring and the ring seat inside the bell shall be wiped clean before the gasket is inserted. Lubricant other than that furnished with the pipe shall not be used. The end of the pipe shall be then forced into the ring to complete the joint.
C. The pipe shall not be deflected either vertically or horizontally in excess of the printed recommendations of the manufacturer.
D. When pipe laying is not in progress, the open ends of the pipe shall be closed to prevent trench water from entering pipe. Adequate backfill shall be deposited on pipe to prevent floating of pipe. Any pipe which has floated shall be removed from the trench, cleaned, and re-laid in an acceptable manner. No pipe shall be laid when, in the opinion of the ENGINEER, the trench conditions or weather are unsuitable for such work.

3.06 FITTINGS

A. All fittings shall be installed utilizing standard installation procedures. Fittings shall be lowered into trench by acceptable means without damage to the fittings. Fittings shall be carefully connected to pipe or other facility, and joint shall be checked to insure a sound and proper joint.

3.07 SANITARY SEWER CLEANOUTS

A. Two-way Sanitary Sewer Clean outs on 4 inch sanitary sewer laterals shall be cast iron ANACO, Two-Way Combination Clean-out; American Brass and Iron; or equal. Sanitary sewer cleanouts on 6 inch and larger pipe shall be a combination Wye and 1/8th bend, ANACO; American Brass and Iron; or equal.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 33 40 00

STORM DRAINAGE SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

perform all earthwork, grading, adjustments of inlets and flushing of all existing systems as shown on the Drawings, described in these specifications, and as required to construct a complete and operable storm water runoff drainage system.

1.0

Specifications) Current Edition.

C. Standard Specifications for Public Works Construction written by the Southern California Chapter, American Public Works Association

1.0

junction boxes and accessories, including gratings, covers and frames.

1.0

been regularly engaged in the design and manufacture of said products and materials for a period of at least 5 years. If the product of an alternate supplier is proposed, it shall be demonstrated to the satisfaction of the Owner's Representative to be of a quality and serviceability equal to the product made by the manufacturer specifically named herein.

B. The Owner will inspect and verify percent of slope.

PART 2 - PRODUCTS

2.0

withstand an AASHTO H-20 loading. Provide interlocking joints where depth requires more than one unit. Minor variations from the drawings may be accepted to permit the use of manufacturer's standard methods of fabrication. Manufacturers: Santa Rosa Cast Products Company; Christy; or equal. Contractor shall be responsible for field verifications for sizing of all storm drain elements.

2.02 STORM DRAINAGE SYSTEM PIPES

1. Pipe and Fittings: Polyvinyl chloride sewer pipe: Less than 12 inches nominal size: ASTM D3034, SDR 26.
2. Joints: Elastomeric gasket joints, ASTM D3212.
3. Gaskets: Submit two sample gaskets with an explanation of the markings.

B. High Density Polyethylene Pipe (HDPE)

1. Pipe: HDPE pipe conforming to ASTM D3212, or ASTM 1417 for pipe sizes over 12-inches (ADS N-12 1B WT pipe or equivalent)

C. Inlets
1. Grates and frames shall be ADA compliant, bicycle-proof and supplied by the manufacturer of the catch basin and be matched to the Drain Inlet.

PART 3 - EXECUTION

3.0

other foreign material. Cleaning shall be by sweeping, flushing with water, or blowing with compressed air, as appropriate for the size and type of pipe. Flushing shall achieve a velocity of at least 3 feet per second. Contractor shall be responsible for collection and disposal of all debris gathered from cleaning operations.

3.02 FIELD TESTING

pressure test in accordance with Section 306-1.4 of the Standard Specifications for Public Works Construction written by the Southern California Chapter, American Public Works Association, et al.

3.03 INSTALLATION OF PRECAST DRAIN INLETS

compacted to 95% relative density. Grout firmly in place to form a tight seal.

B. Install trench drain level and set to grade as indicated in plans. Grout firmly in place to form a tight seal.

END OF SECTION

SECTION 334101

LANDSCAPE DRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Drain Rock.
   2. Geotextile Fabric.
   3. Pipe and Fittings.

B. For Trenching and Backfilling, see Section 31 23 33.

C. For Landscape Maintenance Period, see Section 32 01 00.

D. For Site Concrete, see Section 32 13 16.

E. For Irrigation, see Section 32 84 00.

F. For Soil Preparation and Soil Mixes, see Section 32 91 13.

G. For Planting Area Finish Grading, see Section 32 91 19.

H. For Plant Material, see Section 32 93 00.

I. For Site Storm Drainage Utilities, see Section 33 40 00.

1.2 DEFINITIONS

A. Acceptance: Wherever the terms “acceptance” or “accepted” are used herein, they mean acceptance of Owner’s representative in writing.

B. PVC: Polyvinyl Chloride.

C. SDR: Standard Dimensional Ratio.

1.3 REFERENCES

A. ASTM — American Society for Testing and Materials:
   1. D 698 — Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Most current edition.
   2. D 1557 — Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. Most current edition.
   3. D 2729 — Specification for PVC Sewer Pipe and Fittings. Most current edition.
   4. D 3034 — Specification for Type PSM PVC Sewer Pipe and Fittings. Most current edition.
   5. F 679 — Specification for PVC Large-diameter Plastic Gravity Sewer Pipe and Fittings. Most current edition.

B. Caltrans Standard Specifications – Most current edition.

1.4 SUBMITTALS

A. Product Data:
   1. Pipe and Fittings.
   2. Geotextile Fabric.
   3. Area Drains.
   4. Drain Mat.
   5. Drain Rock.
   6. Drain Board.

B. Shop Drawings:
   1. Trench Drain Frame and Grates.

C. Samples:
   1. Trench Drain Frame and Grates, 12 inches in length.

D. Record Documents:
   1. Maintain on the construction site a record of materials and equipment installed each day.
   2. Daily record information neatly to scale, on full-size prints of the irrigation construction documents.
   3. Include changes, substitutions, and manufacturer's names and catalog numbers for materials and equipment.
   4. Show actual locations of drains, grates, clean-outs and piping.
   5. Show dimensions from easily-identifiable permanent structures such as walls, curbs, buildings or walks.
   6. Procure reproducible sepia mylars of the current construction documents from the Owner's representative.
   7. After Work completion, transfer information noted on prints to the reproducible mylars and submit to the Owner's representative for review of general information content (Owner's representative will not be responsible for errors or omissions).
   8. Contractor shall be responsible for accuracy of information and errors or omissions.
   9. If first submittal is not accepted by Owner's representative, resubmit until accepted.
   10. Submit accepted final record documents to Owner.

1.5 QUALITY ASSURANCE

A. Contractor Qualifications:
   1. Have successfully installed landscape drainage similar to the quality specified for a period of not less than 5 years.
   2. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the Work of this Section.

B. Regulatory Requirements: Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.

1.6 DELIVERY, STORAGE AND HANDLING

A. Storage:
   1. Store products with protection from weather or other conditions which would damage or impair the effectiveness of the product.
   2. Protect PVC pipes and fittings from direct sunlight.
   3. Store pipe on beds equal to or longer than pipe.

1.7 SITE CONDITIONS

A. Environmental Requirements:
   1. Lay and join pipe in dry trenches.

B. Existing Conditions:
   1. Prior to Work commencement review locations of existing public underground utilities and structures with appropriate utility companies and clearly mark in field.
   2. Prior to Work commencement review location of existing private underground utilities and structures with Owner and clearly mark in field.
   3. Prior to Work commencement and after reviewing the Owner's record irrigation documents, review and clearly mark in field heads, valve boxes and other underground equipment, materials and structures.

1.8 WARRANTY

A. General Description: In addition to manufacturer's warranties, warrant Work for a period of one year from date of Final Completion against defects in materials and workmanship.

B. Additional Items Covered: Warranty shall also cover repair of damage to other materials and workmanship resulting from defects in materials and workmanship and trench backfill settlement.

C. Exceptions: Contractor shall not be held responsible for failures due to ordinary wear, neglect by Owner, vandalism, and other causes outside the Contractor's control.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND SUPPLIERS

A. Plastic catch basins, area drains and grates:
   1. National Diversified Sales (NDS) – http://www.ndspro.com.
   2. Or accepted substitute.

B. Drain Mat:
   1. Mirafi – www.tcmirafi.com.
   2. Or accepted substitute.

C. Geotextile fabric:
   1. Mirafi – www.tcmirafi.com.
   2. Carthage Mills – www.carthagemills.com.
   3. Or accepted substitute.

D. Worm drive hose clamps:
   1. McMaster-Carr Supply Company – http://www.mcmaster.com.
   2. Or accepted substitute.

E. Trench Drains:
   1. Urban Accessories – www.urbanaccessories.com.
   2. Or accepted substitute.

F. Vehicular Rated Area Drain:
   1. Urban Accessories – www.urbanaccessories.com.
   2. Or Accepted substitute.

G. Flexible Couplings:
   1. Fernco Inc., Sparks – http://www.fernco.com.
   2. Or accepted substitute.

2.2 MATERIALS

A. Perforated and Solid Non-perforated Pipe:
   1. ASTM D 3350 Cell, Classification 324420C
   2. ASTM D 1248 Type III, Class C, Category 4, Grade P33
   3. AASHTO M252 double-wall, corrugated, HDPE, smooth-interior wall.
   4. Or accepted substitute.

B. Perforated and Solid Corrugated Pipe Fittings:
   1. ASTM F 405, HDPE.
   2. Or accepted substitute.

C. Saddle Fitting for Connections to HDPE Pipe:
   1. Fittings recommended by HDPE pipe manufacturer.
   2. Or accepted substitute.

D. Couplings for Cast-iron Area Drain Pipe to Solid Pipe:
   1. Fernco flexible coupling as recommended by pipe manufacturer.
   2. Or accepted substitute.

E. Plastic Area Drains:
   1. Round flat grates, black color.

F. Trench Drain:
   1. Type: Jamison (7” x 36”)
   2. Finish: Cast Ductile Iron w/ rust conditioner
   3. Color: N/A
   4. Quantity: Continuous

G. Vehicular Rated Area Drain:
   1. Type: Jamison (8 ¾” SQ)
   2. Finish: Cast Ductile Iron w/ rust conditioner
   3. Color: N/A
   4. Quantity: 2

H. Geotextile Fabric:
   1. Mirafi 140 NC (for California Clay Soils – for tree subdrainage and french drains)
   2. Or accepted substitute.

I. Drain Rock:
   1. Crushed clean pea gravel, 1/4-inch diameter.

J. Cleanout for Planting Areas:
   1. Schedule 80 female adaptor with brass male pipe thread plug.

K. Sand Backfill: Durable particles, free of thin or elongated pieces, lumps of clay, soil, loam or vegetable matter, with the following particle size gradation:

Sieve Size (Square)	Percent Passing
4	100
16	80-100
50	20-60
100	10-40
200	0-10

L. Granular Embedment:
   1. Free flowing sandy material which contains no clay, reasonably free of organic material.

M. Planting Area Backfill for Upper 12 Inches:
   1. Upper 12 inches of soil excavated from trenches stockpiled separately on site.

N. Drain Mat:
   1. Mirafi Miradrain 9000.
   2. Or accepted substitute.

O. Water for Sprinkling Backfill:
   1. Clean, potable.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection:
   1. Use every possible precaution to prevent damage to existing conditions to remain.
   2. Provide barricades, fences or other barriers as necessary to protect existing conditions to remain from damage during construction.

3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
4. Submit written notification of conditions damaged during construction to the Owner and Owner's representative within 2 working days of observed damage and before damage is covered.

3.2 TRENCH EXCAVATION

A. Excavation:
1. In planting areas excavate and stockpile separately upper 12 inches of soil to be used later for backfilling upper 12 inches of trenches in planting areas.
2. Pile materials suitable for back-filling a sufficient distance from banks of trenches to prevent slides or cave-ins.
3. Coordinate trench excavation with pipe installation to avoid open trenches for prolonged periods.
4. Excavate width of the trench to provide adequate space for workers to place and joint the pipe or culvert properly, but hold the clear space between the barrel of the pipe and trench wall to the minimum required for a satisfactory installation.
5. Excavate trench to width necessary for sheeting and bracing and proper performance of the Work.
6. Accurately grade bottom of trenches to provide uniform bearing and support for each section of pipe on undisturbed soil or the required thickness of bedding material at every point along its entire length, except for portions of pipe sections where it is necessary to excavate for bell holes and for proper making of pipe joints.
7. Dig depressions for joints after trench bottom has been graded and only 1/2 inch greater length, depth and width than the bell, as required for properly making the particular type of joint, and to insure that the bell does not bear on the bottom of the hole.
8. Over-cut with sand cushion may also be employed for pipe at Contractor's option.
9. Pile excavated material on one side only of trenches to permit ready access to and use of existing fire hydrants, valves, manholes and other utilities system appurtenances.
10. Remove and dispose of excavated materials not required or satisfactory for backfill.
11. Keep surface drainage of adjoining areas unobstructed.
12. Remove water by pumping or other accepted method and discharge at a safe distance from the excavation.

B. Unsatisfactory Fill:
1. When unsatisfactory fill incapable of properly supporting pipe is encountered in bottom of trench, notify Owner and soils engineer in writing.
2. Upon Owner approval, remove unsatisfactory fill to depth accepted by the soils engineer.
3. Backfill over-depths with material accepted by the soils engineer.
4. Compact over-depth fill material to 95 percent as determined by ASTM D 1557.
5. Back-filling of unauthorized over-depths shall be at the expense of the Contractor.

3.3 PIPE INSTALLATION

A. Manufacturer's Requirements: Meet requirements of the manufacturer's current printed instructions.

B. Pipe Laying:
1. Furnish and place in position necessary batter boards, string lines, plummets, graduated poles, etc., required in establishing and maintaining the lines and grades.
2. Protect batter boards and location stakes from possible damage or change of location.

3. Begin laying of the pipe on the prepared foundation at the outlet or downstream end with the spigot or tongue end of the pipe joint pointing downstream and proceed toward the inlet or upstream end with each abutting section of pipe properly matched, true to the established lines and grades.
4. Provide acceptable equipment for hoisting and lowering the sections of pipe into the trench without disturbing the prepared bedding foundation or the sides of the trench.
5. Clean ends of the pipe carefully before the pipe is placed in the trench.
6. As each length of pipe is laid, protect openings to prevent the entrance of earth or bedding material.
7. Fit and match pipe so that when laid in the prepared bedding it will form a smooth, uniform conduit.

C. Jointing: Meet requirements of pipe manufacturer's current printed instructions.

3.4 GEOTEXTILE FABRIC, DRAIN ROCK AND PERFORATED PIPE INSTALLATION

A. Wrapped Drain Rock Around Perforated Pipe:
1. Center fabric strip over trench.
2. Overlap uphill fabric edges over downhill fabric edges a minimum of 12 inches.
3. Install drain rock and pipe as shown on Drawings.
4. After drain rock is installed, fold fabric over top of drain rock with minimum 12 inch overlap.
5. Attach fabric ends to pipe as shown on the Drawings.
6. Immediately backfill 2 inches depth sand layer on lapped fabric.

3.5 TRENCH BACK-FILLING OVER SOLID PIPE

A. General Backfill:
1. Coordinate backfilling with testing of utilities.
2. Where damage is likely to result from withdrawing, leave sheeting in place and cut off a minimum of 24 inches below finished grade.
3. Carefully backfill trenches with granular backfill and deposit in 9 inch maximum layers, loose depth.
4. Bring up granular backfill material evenly on both sides of pipe for its full length and thoroughly and carefully compact until pipe has a cover of not less than 1 foot.
5. Reopen trenches and excavation pits improperly backfilled, or where settlement occurs, to the depth required to obtain the specified compaction, then refill and compact, and restore the surface to the specified grade and compaction.

B. Backfill Under Paving:
1. Backfill as specified above for general backfill, except that remainder of trench above the granular backfill material shall be backfilled with field sand in 6 inch maximum layers, and each layer moistened and compacted to 95 percent of the maximum density obtained at optimum moisture as determined by ASTM D 1557.
2. Backfill to permit the rolling and compaction of the filled trench with the adjoining material to provide the required bearing value so that paving of the area can proceed immediately after backfilling is complete.

C. Backfill in Planting Areas:
1. Backfill as specified above for general backfill except bring granular fill up to 12 inches below finish grade.

2. Compact granular fill to a maximum 75 percent as determined by ASTM D 1557.
3. Backfill upper 12 inches with stockpiled soil from upper 12 inches of trench excavation.
4. Settle upper 12 inches of soil by sprinkling with minimum 2 inches of water.

3.6 FIELD QUALITY CONTROL

A. Field Observation Reviews by Owner's representative: Coordinate and schedule with Owner's representative.

3.7 CLEANING

A. General: Clean and keep clean until Owner accepts maintenance.

END OF SECTION

Laney Library & Learning Resource Center

900 Fallon Street, Oakland, CA 94607

Lighting Catalog Pages

50% Construction Documents Set

8/24/2020

O'MAHONY & MYER
ELECTRICAL ENGINEERING & LIGHTING DESIGN

4340 Redwood Hwy., Suite 245, San Rafael CA 94903

LUMINAIRES (LIGHTING FIXTURES)		
Type	**Description**	**Primary locations**
CA	Recessed Downlight	Public Entrance, Tutorial Seating and Reception, Circulation areas
CB	Recessed Wallwasher	Lobby
CC	Slim Surface Downlight	Restrooms
CD	Recessed 2' x 2' flat panel	Hallways, Storage Rooms, Staff Entry & Delivery
CE	Recessed Linear Wallwasher	Conference Rooms, Group Study Rooms
CG	Micro Profile Linear Surface attached to ceiling grid	Areas with Armstrong Ceiling system
CH	Surface mounted cylinder downlight	Stair A
EX	Exit Sign	Egress paths and doors
GA	In-grade uplight with walkover lens	Uplighting exterior soffit at west end of building
PA	Linear pendant - indirect/direct	Principal lighting fixture throughout the LLRC
PB	Circular pendant - indirect/direct	Group Study Rooms
PC	Service desks Pendant	Circulation, Reference, and other service desks
PD	Circular pendant - indirect/direct	Public Entrance & Lobby
PS	Lensed Striplight - Suspended and Surface-mounted	Electrical, Mechanical, IDF, etc.
TA	Track light and fixtures, surface-mounted and recessed	Art Exhibits
WA	Wall-mounted Linear Indirect/Direct	Stairs
WB	Linear Lensed	Restrooms

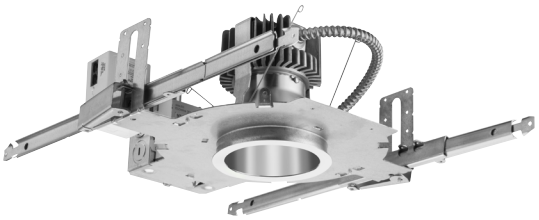
Type	Description	Primary locations
WC	Exterior wall-mounted area light	Roof well
WD	Linear vaportight luminaire with fiberglass housing	Elevator pit & machine room, Pipe room
WF	Steplight	Stair A

gotham® | EVO®

Multiple Layers of Light

Luminaire **CA**
Recessed downlight

General Illumination Round Downlight 4"



Feature Set

- Bounding Ray™ optical design
- Unitized optics mechanically attach the light engine to the lower reflector for complete optical alignment.
- 45° cutoff to source and source image
- Fully serviceable and upgradeable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- Fixtures are wet location, covered ceiling
- Available with 10% dimming, 1% dimming, or dim to dark
- Batwing distribution with feathered edges provides even illumination on horizontal and vertical surfaces
- ENERGY STAR® certified product

Distribution

Superior Perfomance

Nominal Lumens	250	500	750	1000	1500	2000	2500	3000	3500
Delivered Lumens	271	573	808	1001	1527	1994	2580	3110	3612
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7	31.2	38.4
Lumens per Watt	87.4	79.6	102.3	113.8	111.5	102.3	100.4	99.7	94.1

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Healthcare

Special Applications

OVERVIEW

COMPLIMENTARY PRODUCTS

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Design2Ship Quick Ship Program: Options in green text qualify for Design2Ship — 5 business days from order entry to ship. Refer to Design2Ship Brochure for complete program details. **Maximum Order Quantity: 100 units; 50 for Chicago Plenum.**

EXAMPLE: EV04 35/25 AR MWD LSS 120 EZ1

Series	Color Temperature	Nominal Lumen Values	Reflector & Flange Color	Trim Style	Distribution	Finish	Voltage
EV04	27/ 2700 K 30/ 3000 K 35/ 3500 K 40/ 4000 K 50/ 5000 K	02 250 lumens 05 500 lumens 07 750 lumens 10 1000 lumens 15 1500 lumens 20 2000 lumens 25 2500 lumens 30 3000 lumens 35 3500 lumens	AR Clear PR Pewter WTR Wheat GR Gold WR[1] White BR[1] Black WRAMF[1] White Anti-microbial	(blank) Self-flanged FL Flangeless	MD Medium (0.9 s/mh) MWD Medium wide (1.0 s/mh) WD Wide (1.2 s/mh)	LSS Semi-specular LD Matte-diffuse LS Specular	MVOLT 120 277 347[2,3]

Driver[4]		Control Interface		Options	
GZ10	0-10V driver dims to 10%	NLT[6]	nLight® dimming pack controls	SF	Single Fuse. Specify 120V or 277V
GZ1	0-10V driver dims to 1%	NLTER[2,6,10]	nLight® dimming pack controls emergency circuit	TRW[7]	White painted flange
EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.	NLTAIR2[13]	nLight® Air enabled	TRBL[8]	Black painted flange
EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.	NLTAIRER2[2,10,13]	nLight® AIR Dimming Pack Wireless Controls. Controls fixtures on emergency circuit	EL[9]	Emergency battery pack, 10W, with integral test switch
EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.	EXA1	XPoint Wireless, eldoLED 0-10V ECOdrive. Linear dimming to 1%. Refer to XPoint tech sheet.	ELR[9]	Emergency battery pack, 10W, with remote test switch
EDAB[4]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	EXAB	XPoint Wireless, eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%. Refer to XPoint tech sheet.	ELSD[9]	Emergency battery pack, 10W, with self-diagnostics, integral test switch
EDXB[4]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. Minimum 1000 lumens. Includes termination resistor. Refer to DMXR Manual.			ELRSD[9]	Emergency battery pack, 10W, with self-diagnostics, remote test switch
ECOS2[5]	Lutron® Hi-Lume® 2-wire forward-phase driver.120V only. Minimum dimming level 1%. Minimum 1000 lumens.			E10WCP[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with integral test switch
ECOD[5]	Lutron Ecosystem digital Hi-Lume 1% soft-on, fade to black			E10WCPR[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with remote test switch
				N80[11]	nLight® Lumen Compensation
				BGTD	Bodine generator transfer device. Specify 120V or 277V.
				90CRI	High CRI (90+)
				CP[12]	Chicago Plenum. Specify 120V or 277V for 5000lm and above.
				RRL__	RELOC®-ready luminaire connectors enable a simple and consistent factory installed option across all ABL luminaire brands. Refer to RRL for complete nomenclature.

ACCESSORIES — order as separate catalog numbers (shipped separately)

SCA4	Sloped ceiling adapter. Degree of slope must be specified (5D, 10D, 15D, 20D, 25D, 30D). Ex: SCA4 10D. Refer to TECH-190.
CTA4-8 YK	Ceiling thickness adapter (extends mounting frame to accommodate ceiling thickness up to 5"). Adds ~4" to fixture height.
ISD BC	0-10V wallbox dimmer. Refer to ISD-BC.

ORDERING NOTES

1. Not available with finishes.
2. Not available with emergency battery pack options.
3. Supplied with factory installed step down transformer.
4. Refer to TECH-240 for compatible dimmers.
5. Not available with nLight® and XPoint options.
6. Must specify voltage.
7. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not applicable with WR (white reflector) or FL (flangeless) option.
8. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not applicable with BR (black reflector) or FL (flangeless) option.
9. 11" of plenum depth or top access required for battery pack maintenance.
10. ER for use with generator supply power. Will require an emergency hot feed and normal hot feed.
11. Fixture begins at 80% light level. Must be specified with NLT or NLTER. Only available with EZ10 and EZ1 drivers.
12. Not available with ELR, HAO, EXA1, or EXAB options.
13. Not available DALI or DMX drivers. Not available with CP or N80 options. Not recommended for metal ceiling installations.

SPECIFICATIONS

Optical Assemby

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Optical design is a Bounding Ray™ design with 45° cutoff to source and source image. Top-down flash characteristic for superior glare control.

Unitized optics shall have mechanical attachment of the light engine to the lower reflector for complete optical alignment.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum, solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired or wireless network with integral power supply as per specification.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32” and minimum 15” extension and 4” vertical adjustment.

Luminaires shall be suitable for installation in ceilings up to 1½” thick. (specify ceiling thickness adapter to extend frame to accommodate ceiling thickness up to 2”).

Tool-less adjustments shall be possible after installation.

The assembly and manufacturing process for the luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

25°C ambient temperature standard (1/2” clearance on all sides from non-combustible materials in non-IC applications, unless marked spacing noted otherwise). For use in insulated ceilings, a 3" clearance on all sides from insulation is required (unless marked spacing noted otherwise).

Listings

Fixtures are CSA certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the “Standards for Safety” to UL, wet location covered ceiling. Luminaire configurations are Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization. Visit www.energystar.gov for specific configurations listed.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by a point at the intersection of the CCT line and the black body locus line in CIE chromaticity space.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.

All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands’ specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

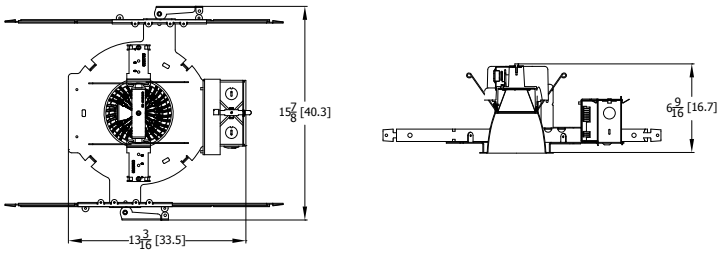
To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

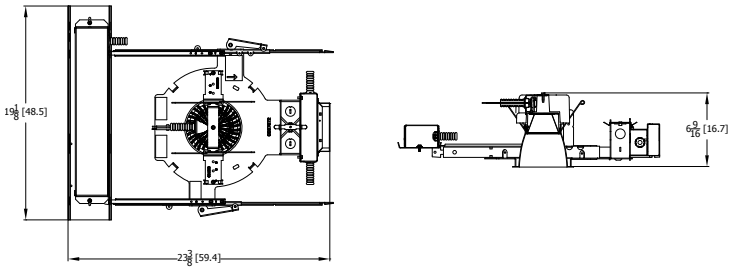
DIMENSIONAL DATA

Aperture: 4-5/16" (11)	Ceiling Opening: 5-1/8" (13) self-flanged
Overlap trim: 5-7/16" (13.8)	5-1/4" (13.3) flangeless

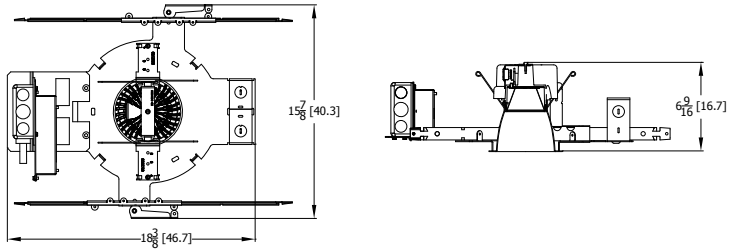
Standard



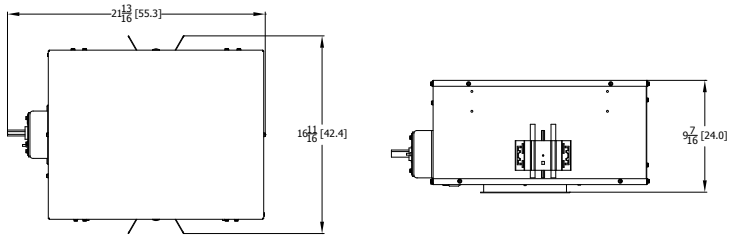
Battery Pack



CP Standard



CP Enclosed For Use With Battery Pack & nLight

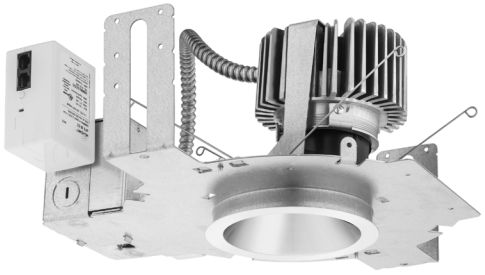


gotham® | EVO®

Multiple Layers of Light

Luminaire **CB**
Recessed wallwasher

General Illumination Lensed Wallwash 4"



OVERVIEW

Feature Set

- Bounding Ray™ optical design
- Unitized optics mechanically attach the light engine to the lower reflector for complete optical alignment.
- 45° cutoff to source and source image
- Fully serviceable and upgradeable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- Fixtures are wet location, covered ceiling
- Available with 10% dimming, 1% dimming, or dim to dark
- Anodized kicker reflector provides uniform illumination from floor to ceiling

Distribution

wallwash

Superior Perfomance

Nominal Lumens	250	500	750	1000	1500	2000	2500	3000	3500
Delivered Lumens	229	229	590	733	1116	1462	1886	2274	2653
Wattage	3.1	7.2	7.9	8.8	14.7	19.7	25.7	31.2	38.4
Lumens per Watt	0.0	0.0	74.7	83.3	75.9	74.2	73.4	72.9	69.1

COMPLIMENTARY PRODUCTS

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Downlight | Adjustable | Open Wallwash | Lensed Wallwash | Cylinder | Pinhole | Bevel | Hyperbolic

Healthcare

MRI | Surgical Suite | Patient Room

Special Applications

Dynamic | Food Service | Vandal/Tamper | Clean Room | Shower | Steam Room

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Design2Ship Quick Ship Program: Options in green text qualify for Design2Ship — 5 business days from order entry to ship. Refer to Design2Ship Brochure for complete program details. **Maximum Order Quantity: 100 units; 50 for Chicago Plenum.**

EXAMPLE: EV04LW 35/10 ARFL LSS 120 EZ1

Series	Color Temperature	Nominal Lumen Values	Aperture & Trim Color	Trim Style	Finish	Voltage
EV04LW	27/ 2700 K 30/ 3000 K 35/ 3500 K 40/ 4000 K 50/ 5000 K	02 250 lumens 05 500 lumens 07 750 lumens 10 1000 lumens 15 1500 lumens 20 2000 lumens 25 2500 lumens 30 3000 lumens 35 3500 lumens	AR Clear PR Pewter WTR Wheat GR Gold WR[1] White BR[1] Black	(blank) Self-flanged FL Flangeless	LSS Semi-specular LD Matte diffuse LS Specular	MVOLT 120 277 347[2,3]

Driver[4]	
GZ10	0-10V driver dims to 10%
GZ1	0-10V driver dims to 1%
EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.
EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.
EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.
EDAB[5]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.
EDXB[5]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. Minimum 1000 lumens. Includes termination resistor. Refer to DMXR Manual.
ECOS2[5]	Lutron® Hi-Lume® 2-wire forward-phase driver. Minimum dimming level 1%. Minimum 1000 lumens. 120V only.
ECOD[5]	Lutron Ecosystem digital Hi-Lume 1% soft-on, fade to black

Control Interface	
NLT[6]	nLight® dimming pack controls
NLTER[2,6,10]	nLight® dimming pack controls emergency circuit
NLTAIR2[13]	nLight® AIR enabled
NLTAIRER2[2,10,13]	nLight® AIR enabled wireless dimming pack. Controls fixture on emergency circuit
EXA1	XPoint Wireless, eldoLED 0-10V ECOdrive. Linear dimming to 1%. Refer to XPoint tech sheet.
EXAB	XPoint Wireless, eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%. Refer to XPoint tech sheet.

Options	
SF	Single fuse. Specify 120V or 277V.
TRW[7]	White painted flange
TRBL[8]	Black painted flange
ELR[9]	Emergency battery pack with remote test switch
ELRSD[9]	Emergency battery pack with self-diagnostics, remote test switch
E10WCPR[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with remote test switch
N80[11]	nLight® Lumen Compensation
BGTD	Bodine generator transfer device. Specify 120V or 277V.
CRI90	High CRI (90+)
CP[12]	Chicago plenum. Specify 120V or 277V for 5000lm and above.
RRL__	RELOC®-ready luminaire connectors enable a simple and consistent factory installed option across all ABL luminaire brands. Refer to RRL for complete nomenclature.

ACCESSORIES — order as separate catalog numbers (shipped separately)

ISD BC	0-10V wallbox dimmer. Refer to ISD-BC.

ORDERING NOTES

1. Not available with finishes.
2. Not available with emergency battery pack options.
3. Supplied with factory installed step down transformer.
4. Refer to TECH-240 for compatible dimmers.
5. Not available with nLight® and XPoint options.
6. Must Specify voltage.
7. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not available with WR (white reflector), or FL option.
8. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not available with BR (black reflector), or FL option.
9. 11" of plenum depth or top access required for battery pack maintenance.
10. For use with generator supply EM power. Will require an emergency hot feed and normal hot feed.
11. Fixture begins at 80% light level. Must be specified with NPS80EZ or NPS80EZER.
12. Battery pack not available. 2500 lumen max.
13. Not available DALI or DMX drivers. Not available with CP or N80 options. Not recommended for metal ceiling installations.

SPECIFICATIONS

Optical Assemby

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Unitized optics shall have mechanical attachment of the light engine to the lower reflector for complete optical alignment.

Wallwash enables uniformity from floor to ceiling. Smooth, balanced illumination optimized for ceilings of 8' to 12' with recommended spacing of 3' from wall and 3' centers.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum, solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired or wireless network with integral power supply as per specification.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32" and minimum 15" extension and 4" vertical adjustment.

Luminaires shall be suitable for installation in ceilings up to 1½" thick.

Tool-less adjustments shall be possible after installation.

The assembly and manufacturing process for the SSL luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

25°C ambient temperature standard (1/2" clearance on all sides from non-combustible materials in non-IC applications, unless marked spacing noted otherwise). For use in insulated ceiling, a 3" clearance on all sides from insulation is required (unless marked spacing noted otherwise).

Listings

Fixtures are CSA certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL, wet location covered ceiling.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by a point at the intersection of the CCT line and the black body locus line in CIE chromaticity space.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.

All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

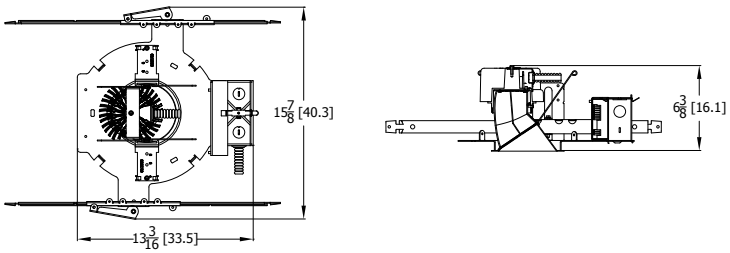
To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

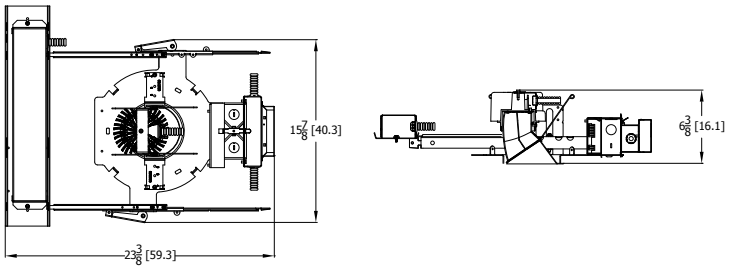
DIMENSIONAL DATA

Aperture: 4-5/16" (11)	Ceiling Opening: 5-1/8" (13) self-flanged
Overlap trim: 5-7/16" (13.8)	5-1/4" (13.3) flangeless

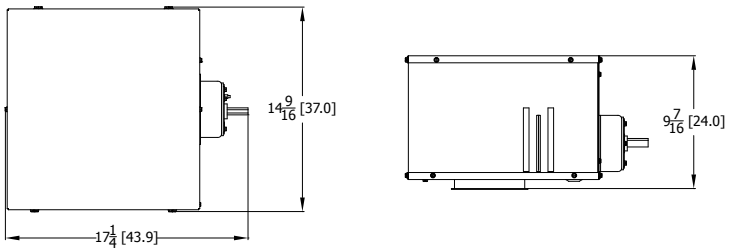
Standard



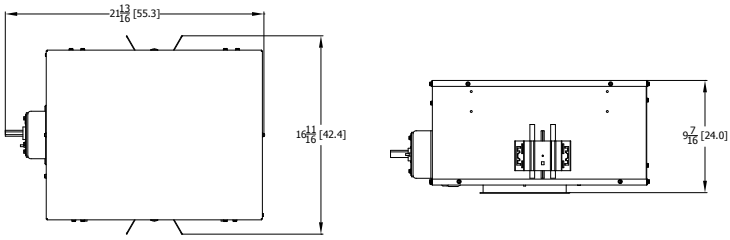
Battery Pack



CP Standard



CP Enclosed



DRD5S & SurfaceFrame

Surface Mount LED Downlight

New Construction

DRDHNJO Octagonal Junction Box

Luminaire **CC**
Slim surfacedownlight

Spec Sheet V- 01.15.20

- Thinnest-in-class DRD5S delivers the pure, smooth light and the elegant look of a high-end recessed downlight
- Features multiple ratings to meet the demands of a wide range of situations
- Ultra-low profile allows it to install in as little as 2" of ceiling space when 5/8" drywall is used

Application
New Construction

Aperture
4" Octagonal Junction Box

Delivered Lumens
750 lm (9.0W), 1000 lm (12.0W)

Color Quality
90+ CRI, < 3-step SDCM

Color Temperature
2700K 3000K 3500K

Optics
General

Input Voltage
120/277V

Dimming
TRIAC/ELV 5%
0-10V 1%

Emergency Lighting
Optional Emergency LED Driver with integrated Test Switch for lighting up to 90 minutes in event of power failure

Shape
Round, Square

Finish
White

Housing Ratings

- Code compliant for use in appropriate fire-rated assemblies up to a maximum of 2-hours
- STC/IIC Sound Rated
- ASTM E283 Certified Air Tight
- IC (Insulation Contact) Rated

Module Ratings

- UL Listed for Wet Location

Standards
JA8 TITLE 24 · ENERGY STAR · cULus LISTED

Guarantee
50,000 hrs | 5 years

Additional Options
Non-Conductive Dead Front

PRODUCT BUILDER

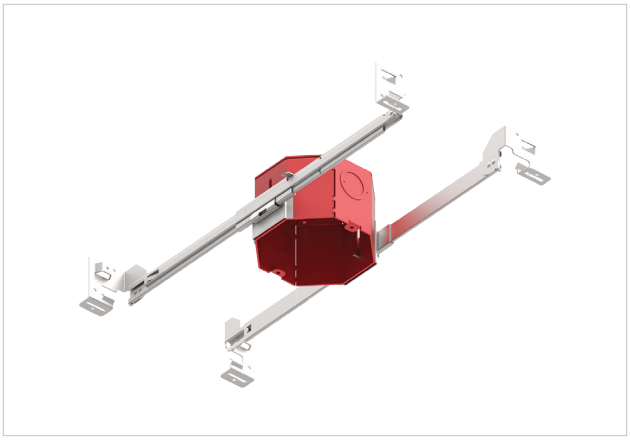
HOUSING

PRODUCT CODE		APPLICATION		APERTURE		OPTION	
DRDH	Housing	**N**	New Construction	**JO**	SurfaceFrame Octagonal Junction Box	**[Blank]**	Integrated Driver
						7OSEM	EM Driver[1], 0-10V, 750 lm
						10OSEM	EM Driver[1], 0-10V, 1000 lm

LED MODULE

PRODUCT CODE		APERTURE		SHAPE		LUMENS		CRI		CCT		DRIVER	
DRD5S	Module	**4**	4" Aperture	**R**	Round	**07**	750 lm	**9**	90+ CRI	**27**	2700K	**[Blank]**	Integrated TRIAC/ELV
				S	Square	**10**	1000 lm			**30**	3000K	**O**	Integrated 0-10V
										35	3500K	**DF**	Integrated TRIAC/ELV, Non-Conductive[2]
												ODF	Integrated 0-10V, Non-Conductive[2]
												EM	Emergency[1] w/ Test Switch

[1] EM option (housing) and Emergency driver (module) must be selected together
[2] Only available for Round shape, 750 lm, 2700K or 3000K CCT



SurfaceFrame

New Construction Octagonal Junction Box

DRDHNJO

SUMMARY

JUNCTION BOX: Equipped with (4) ½" trade size knockouts (two side, two top) to allow straight conduit runs. Approved for 6 (three in, three out) #12 AWG 70°C through wiring conductors.

MOUNTING: Pre-installed mounting brackets allow vertical adjustment of bar hangers up to 1"

CEILING: ½" up to 1 ¾"

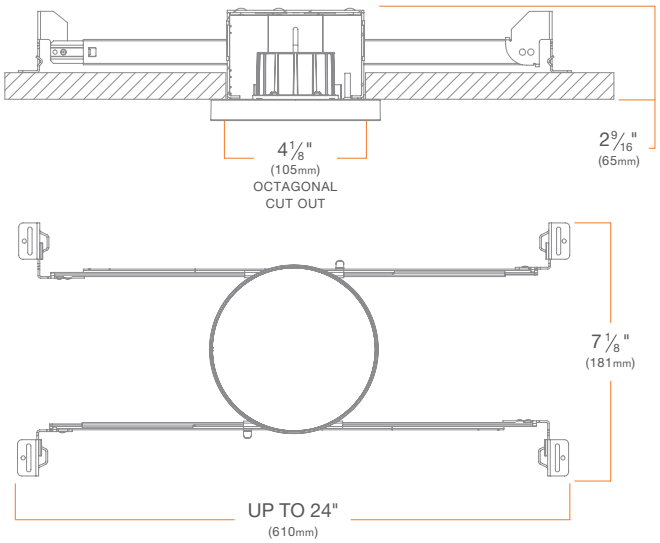
CUTOUT: 4 ⅛" (105mm) octagonal opening

LISTINGS: Metallic outlet box certified UL514A, code compliant for use in appropriate fire-rated assemblies for up to 2-hours, STC/IIC Sound Rated, ASTM E283 certified Air Tight, IC (Insulation Contact) rated

WARRANTY: 5 year limited warranty

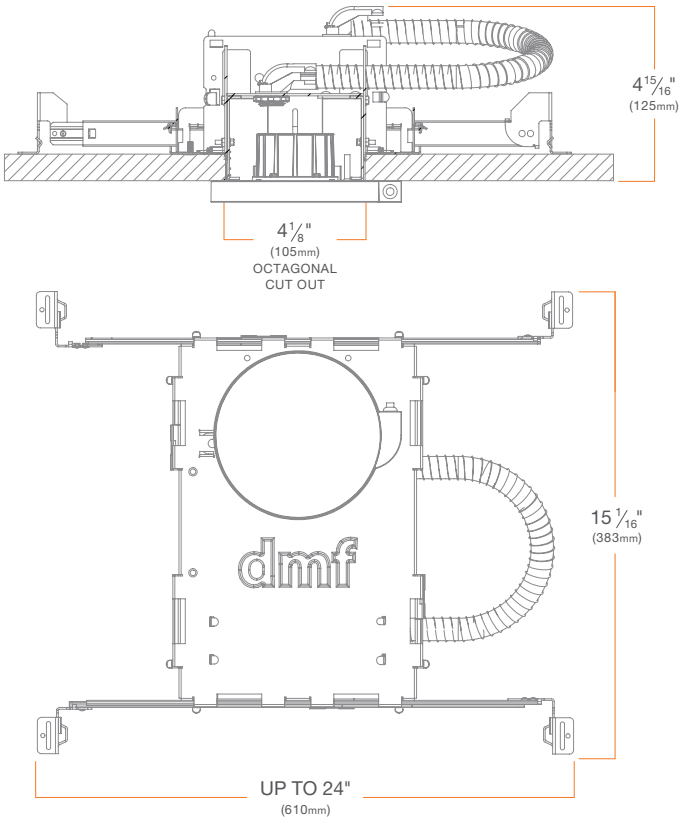
SurfaceFrame

DRDHNJO



SurfaceFrame w/ Emergency Lighting

DRDHNJO EM



MODULE

DRD5S

Surface Mount LED Module

DRD5S

SUMMARY

LED: Optimized LED array

SHAPE: 4" Round, 4" Square

MODULE LUMENS: 750 lm (9.0W), 1000 lm (12.0W)

COLOR QUALITY: 90+ CRI, less than 3-step SDCM

CCT: 2700K, 3000K, 3500K

INPUT VOLTAGE: 120/277V

DIMMING: Down to less than 5% for TRIAC/ELV at 120V, 1% for 0-10V at 120/277V

MAX INPUT CURRENT (120V): 0.075 amps, 0.1047 amps

MAX INPUT CURRENT (277V): 0.034 amps, 0.047 amps

POWER FACTOR: Greater than 0.9

TOTAL HARMONIC DISTORTION: Less than 20%

AMBIENT OPERATING TEMPERATURE: -20°C to 40°C

EMERGENCY LIGHTING: Optional Emergency LED Driver with Integrated Test Switch for lighting up to 90 minutes in event of power failure

PHOTOMETRIC TESTING: Tested in accordance to IESNA LM-79-2008

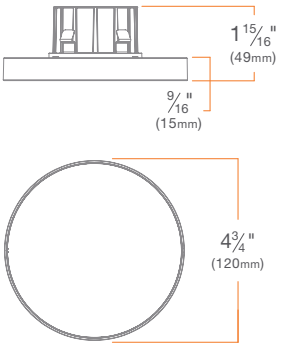
LISTINGS: ENERGY STAR® qualified, California Title 24 2016 JA8 compliant, UL Listed for Wet Location, cULus Listed

LIFETIME: 50,000 hours at 70% lumen maintenance

WARRANTY: 5 year limited warranty

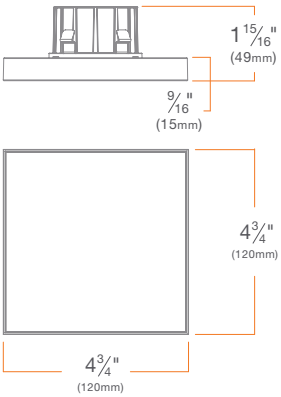
4" Round

DRD5S4R



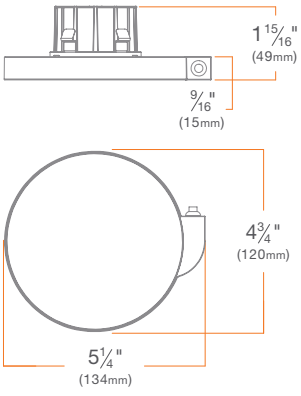
4" Square

DRD5S4S



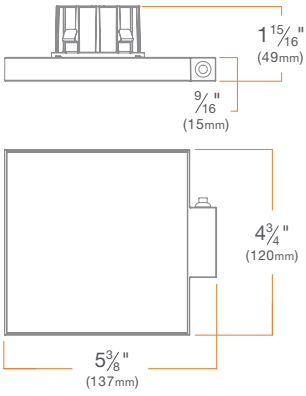
4" Round w/ EM Test Switch

DRD5S4R EM



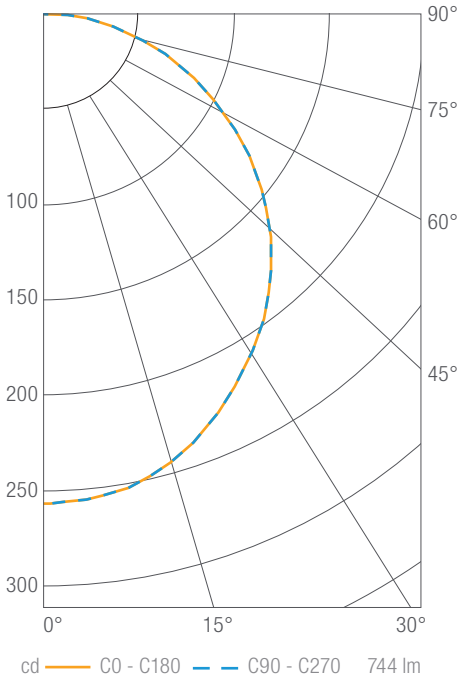
4" Square w/ EM Test Switch

DRD5S4S EM



PHOTOMETRY

DRD5S 4" Round, 750 lm, 90 CRI, 3000K DRD5S4R07930



Luminous Intensity

Gamma	C 0˚
0º	258
5º	256
10º	253
15º	247
20º	237
25º	226
30º	213
35º	200
40º	185
45º	169
50º	151
55º	132
60º	113
65º	93
70º	73
75º	54
80º	35
85º	18
90º	6

Values in candela

Zonal Lumen Summary

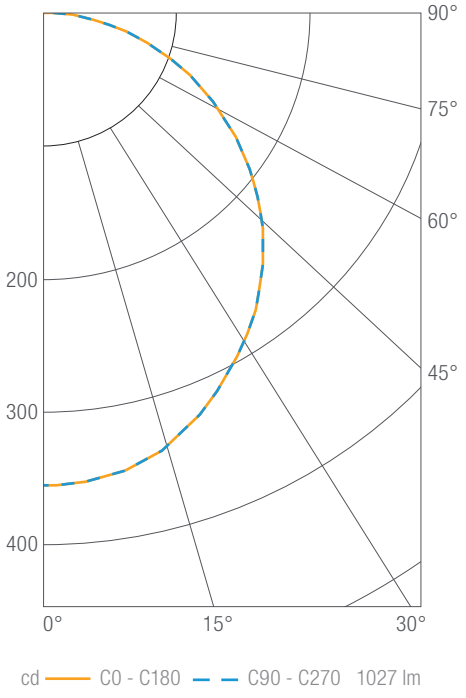
Zone	Lumens	Luminaire %
0-30	199	27
0-40	324	44
0-60	573	77
0-90	744	100
0-180	744	100

Illuminance Chart

Distance from LED	Foot Candles	Diameter
3.0'	29	8.8'
6.0'	7	17.7'
9.0'	3	26.5'
12.0'	2	35.3'

Beam Angle: 70°

DRD5S 4" Round, 1000 lm, 90 CRI, 3000K DRD5S4R10930



Luminous Intensity

Gamma	C 0˚
0º	356
5º	354
10º	349
15º	340
20º	327
25º	312
30º	294
35º	276
40º	255
45º	233
50º	209
55º	183
60º	155
65º	128
70º	101
75º	74
80º	48
85º	25
90º	9

Values in candela

Zonal Lumen Summary

Zone	Lumens	Luminaire %
0-30	274	27
0-40	447	44
0-60	790	77
0-90	1027	100
0-180	1027	100

Illuminance Chart

Distance from LED	Foot Candles	Diameter
3.0'	40	8.8'
6.0'	10	17.7'
9.0'	4	26.5'
12.0'	2	35.3'

Beam Angle: 63°

DIMMER COMPATIBILITY

Recommended Phase-control Dimmers (Dims down to 5% nominal measured light output)

Brand	Series	Model Number	Max Load 750lm DRD5S4R07	Max Load 1000lm DRD5S4R10
Cooper	Aspire	9573	29	23
Leviton	Vizia	VPE06	64	48
Lutron	CL Series	AYCL-253, DVCL-253	26	20
	Grafik Eye 3000	QSGR-3P, QSGR-6P	31	24
	Grafik Sys / Homeworks	RPM-4U	44	35
	Maestro CL	MACL-153M, MSCL-OP153M, MSCL-VP153M	16	12

Compatible Phase-control Dimmers[1] (Dims down to 20% nominal measured light output)

Brand	Series	Model Number	Max Load 750lm DRD5S4R07	Max Load 1000lm DRD5S4R10
Cooper	Aspire	9573	29	23
	Decorator	DLC03P, DAL06P	29	23
Legrand	Adorne	ADTP703	48	38
	Digital Light Management	LMRC-221	250	195
Leviton	IllumaTech	IPE04	32	25
	Vizia	VPE04	42	32
	Vizia	VPE06	64	48
Lutron	CL Series	AYCL-153, CTCL-153, DVCL-153, LGCL-513, SCL-153, TGCL-513	15	11
	CL Series	AYCL-253, DVCL-253	26	20
	Grafik Eye 3000	QSGR-3P, QSGR-6P	31	24
	Grafik Sys / Homeworks	RPM-4U	44	35
	Maestro CL	MACL-153M, MSCL-OP153M, MSCL-VP153M	16	12
	Maestro Wireless	MRF2-6ELV, MRF2-6CL	15	12
	Radio RA	RRD-6NA, RRD-6CL, RRD-6D	15	12
	Skylark Contour CL	CTCL-153P	15	12

[1] Dimmer compatibility reflects performance compatibility only. Please reference your local codes for application.

SurfaceFrame Options

Shallow Recessed LED Downlight

DRD2 & SurfaceFrame
DRDHNJO Octagonal Junction Box

DRD2 & SurfaceFrame Alt/EM
Alternate Dimming and/or Emergency Lighting
DRDHNJO Octagonal Junction Box

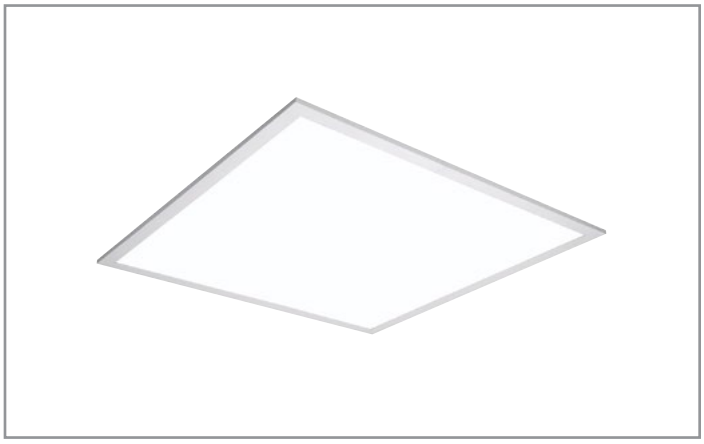
Apex Series Shallow Recessed LED Downlight

DRD2X & SurfaceFrame
DRDHNJO Octagonal Junction Box

DRD2X & SurfaceFrame Alt/EM
Alternate Dimming and/or Emergency Lighting
DRDHNJO Octagonal Junction Box

Surface Mount LED Downlight

DRD5S & SurfaceFrame
DRDHNJO Octagonal Junction Box



Metalux

22FP LED

2' x 2' General LED Panel
Recessed in Insulated Ceilings or
Suspended/Surface Mount

Typical Applications

• Commercial Office Spaces • Schools • Healthcare
• Retail Merchandising Areas

Interactive Menu

Product Certification

Product Features

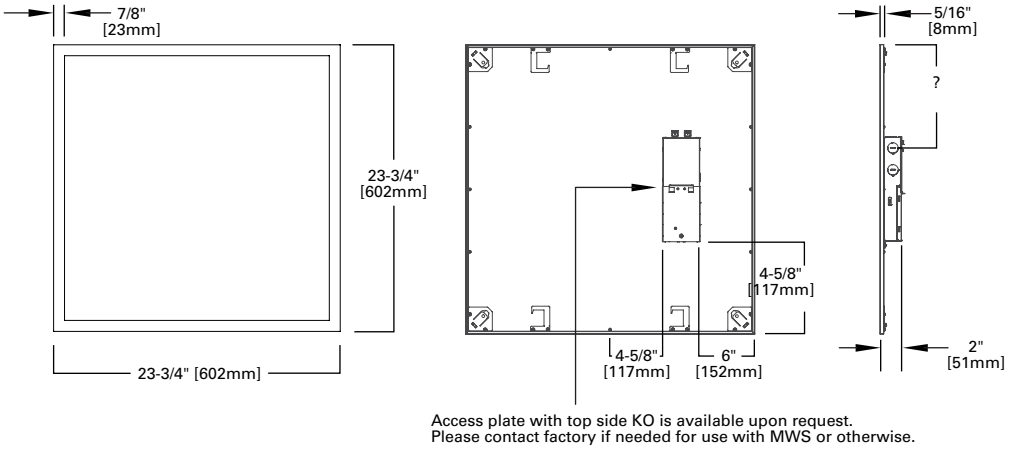
Connected Systems

MWS MODULAR WIRING SYSTEM CLICK HERE

Top Product Features

- Ultra thin less than 2" height fits shallow plenums with room to spare
- Models from less than 20W and High Lumen models up to 7000 lumens
- HE models at 136 lumens per watt deliver up to 60% energy savings
- Stock CCT in 80 CRI @ 3000K, 3500K, 4000K, 5000K and 90 CRI 3000K
- Easy to install - wire and wire nuts included

Dimensional and Mounting Details



Access plate with top side KO is available upon request.
Please contact factory if needed for use with MWS or otherwise.

Ordering Information/Performance

Standard Options

Catalog	UPC	CCT	CRI (Min)	Delivered Nominal Lumens	Watts	Efficacy (lm/W)	Input Current (A) 120V	Input Current (A) 277V
22FP4235C	080083833580	3500K	80	4572	38.3	119	.32	.14
22FP4240C	080083833603	4000K	80	4465	38.3	117		
22FP4250C	080083833627	5000K	80	4659	41.4	113	.35	.15
22FP3235C	080083833528	3500K	80	3333	29.2	114	.24	.11
22FP3240C	080083833542	4000K	80	3333	29.2	114		
22FP3250C	080083833566	5000K	80	3331	30.0	111	.25	
22FP3830C9 (1)	080083833801	3000K	90	3654	39.1	93	.34	.15
22FP2830C9 (1)	080083833788	3000K	90	2734	29.5	93	.26	.11
22FP2535HE	080083824090	3500K	80	2610	20.1	130	.17	.07
22FP2540HE	080083824113	4000K	80	2551	19.6	130		
22FP2130C	080083823994	3000K	80	2318	20.7	112	.18	.08
22FP2135C	080083824014	3500K	80	2205	20.7	107		
22FP2140C	080083824038	4000K	80	2494	20.7	121		

Notes : (1) May have extended lead times.

347V Options

Catalog	UPC	CCT	CRI (Min)	Delivered Nominal Lumens	Watts	Efficacy (lm/W)	Input Current (A) 347V
22FP4235C-347V	80083885480	3500K	80	4330	37.3	116	.111
22FP4240C-347V	80083876723	4000K	80	4465	37.3	120	
22FP4250C-347V	80083885565	5000K	80	4572	37.3	123	

Options/Ordering Information

ATW-SW4=Chicago Rated and IP5X ingress protection (3)
Example catalog number=ATW-SW4-22FP3240C

EL14W=EBPLED14W battery installed (2)
EL7W=EBPLED7W battery installed (2)
Example catalog number=22FP3240C-EL14W

A3/8-5D/18G=6' 3/8" flex with dimming leads installed
Example catalog number=22FP3240C-A3/8-5D/18G

Notes : (2) Indicator/test switch to be installed separately. For approximate delivered lumens multiply the lumens per watt of the desired fixture by the wattage of the emergency battery pack (100 lm/W x 7=700 lumens). (3) May not be used with EL7W, EL14W or Flex options.

Load Data (Stock Product)

Thd	14%
Power Factor	0.96
Weight	9.4 lbs
Low Temp. Start	-20°C

Shipping Data

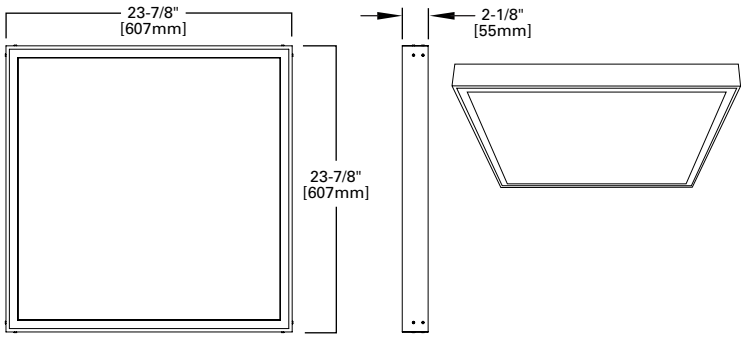
Fixture Size	Wt.	Pallet Size	Units per Pallet
2' x 2'	12 lbs.	53" x 30"	44

Accessories/Ordering Information

Surface Mount Kit (3)

Catalog	UPC
FPSURF22	080083802722

Notes : (3) May not be used with EL7W or EL14W options.



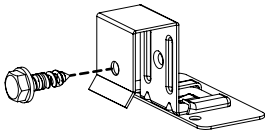
Drywall Frame Kit

Catalog	UPC
DF-22W-U	662401232963

Ceiling Retention

Catalog	UPC
FPEQ	080083802685

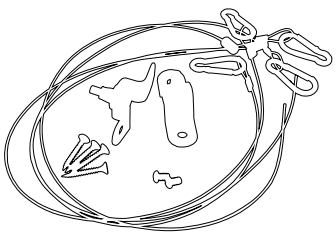
Required by some local codes. Order one set for each fixture (Four clips per kit)



Suspension Kit

Catalog	UPC
FPSUS2	080083802784

Mounting height from ceiling
Min.=7-1/4" [184mm]
Max.=27" [286mm]



Product Specifications

Construction
- Narrow aluminum bezel is tightly held to code gauge steel back plate
- Seamless corners to maximize the light emitting surface with a refined finish

Mounting
- Integral grid locking clips and separate suspension clips provided for installation flexibility when additional retention is required
- Junction box constructed of code gauge galvanized steel with and easy access hinged door
- Multiple Trade size KO provided and JBox is suitable for up to 12AWG wiring
- Stock luminaire is less than 2" for use in shallow plenum or low ceiling spaces
- Surface or suspension mounting kits available
- ATW-SW4 option is available for CCEA compliance and provides full IP5X rating
- Factory installed flexible cable with dimming leads options available

Controls
- Standard UNV 120 - 277V driver with 0-10V dimming to 10% standard
- Compatible with field installed wireless controls available for either Wavelinx of LumaWatt Pro

Electrical
- Standard and High Efficacy models available
- LED's available in 3000K, 3500K, 4000K, and 5000K with a minimum of 80 CRI
- 90 CRI available with 3000K
- Projected lumen maintenance based on TM21 testing standards is L73 > 60,000 hours
- Emergency battery pack options available in 7w and 14w options
- Battery pack options available as factory installed or field installed for remote mounting

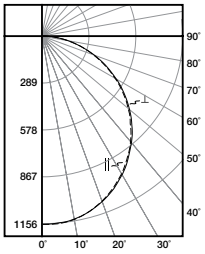
Optical Shielding
- Acrylic light guide with specialized features to optimize light extraction
- White frost lens with smooth pattern for uniform illumination
- Scratch and impact resistant

Compliance
- Indoor luminaires are cULus listed for 25C ambient environments
- IC rated for direct insulation contact
- RoHS compliant
- Damp location listed
- IESNA LM-79 and LM-80 standards compliant
- DesignLights Consortium® Qualified and classified for both DLC Standard and DLC Premium, refer to www.designlights.org for details.
- Can be used for State of California Title 24 high efficacy luminaire

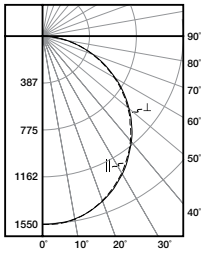
Warranty
- Five year warranty.

Photometric Data

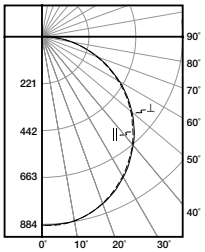
View IES files



22FP3240C
Electronic Driver
Linear LED 4000K
Spacing criterion: (II) 1.25 x mounting height, (⊥) 1.26 x mounting height
Lumens: 3333
Input Watts: 29.2W
Efficacy: 114.1 LPW
Test Report: 22FP3240C.IES



22FP4240C
Electronic Driver
Linear LED 4000K
Spacing criterion: (II) 1.25 x mounting height, (⊥) 1.26 x mounting height
Lumens: 4465
Input Watts: 38.3W
Efficacy: 116.6 LPW
Test Report: 22FP4240C.IES



22FP2540HE
Electronic Driver
Linear LED 4000K
Spacing criterion: (II) 1.25 x mounting height, (⊥) 1.26 x mounting height
Lumens: 2551
Input Watts: 19.6W
Efficacy: 130.2 LPW
Test Report: 22FP2540HE.IES

Control Systems

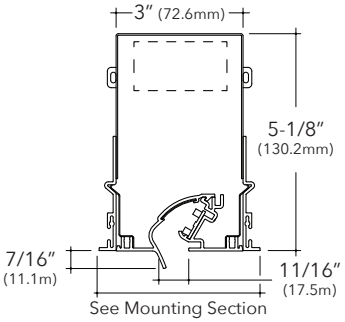
- WaveLinx
- DLVP
- LumaWatt Pro
- iLumin Plus
- VividTune

Connected Systems CLICK HERE

Cooper Lighting Solutions
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

PINNACLE
ARCHITECTURAL LIGHTING®

Luminaire **CE**
Recessed linear wallwasher



EDGE EV3WW

3" Recessed Linear Wall Wash

Key Features

- Extruded aluminum trim with formed cold rolled 20 gauge steel back box housing
- Highly reflective, die-formed white, painted steel reflector
- 5-year limited warranty covers LED, driver and fixture
- UL and cUL listed. IC rated
- Approved for dry/damp location unless otherwise noted
- Maximum fixture weight is 15lbs (per 4ft fixture)
- Room-Side Maintenance for LED system
- Designed to be mounted facing wall between 12"-18" from wall
- Buy American Act compliant

LED · 5 YEAR LED WARRANTY · QUICKSHIP · c UL us · IC RATED · Made in AMERICA

Example Part #: EV3WW-830HO-26'-G1-U-OL1-1-0-W

EV3WW - [CRI, CCT & OUTPUT] - [LENGTH] - [MOUNTING] - [VOLTAGE] - [DRIVER] - [CIRCUITING] - [BATTERY & EMERGENCY] - [FINISH] - [FIXTURE OPTIONS]

_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _
CRI, CCT & OUTPUT QS[1]	**LENGTH**[2]	**MOUNTING**[3]	**VOLTAGE**
_27_ _ - 2700K **_30_ _** - 3000K **_35_ _** - 3500K **_40_ _** - 4000K **CL_ _ _ _ _ _** - Custom Lumens **CW_ _ _ _ _ _** - Custom Watts *Lumen Output pg. 2* *Example: 830HO is **8** = 80 CRI; **30** = 3000K; **HO** = High Output; Blank = Standard Output*	**_ _** - Individual Fixture QS **_ _** - Continuous Row QS *Length and Pattern pg. 2*	**G1(G)** - 1" *(15/16")* T Bar QS **G9(G)** - 9/16" T Bar QS **GB(G)** - 9/16" Bevel T Bar **GS(G)** - Screw Slot T Bar QS **FL(F)** - 1/2" Flange QS **NF(N)** - Non Flange QS **SF(S)** - Spackle Flange *Mounting pg. 3*	**U** - Universal QS *(120 thru 277V)* **1** - 120V QS **2** - 277V QS **3** - 347V *Voltage pg. 3*

_ _ _ _ _ _	_	_ _ _	_ _ _
DRIVER	**CIRCUITING**	**BATTERY & EMERGENCY**[4]	**FINISH**
OL1 - Osram *(10%, 0-10v, standard)* QS **OL2** - Osram *(1%, 0-10v)* **OL3** - Osram 347v *(10%, 0-10v)* **EE1** - eldoLED ECOdrive *(1%, 0-10v)* **ES1** - eldoLED SOLOdrive *(0%, 0-10v)* **LH1**- Lutron Hi-lume *(1%, EcoSystem)* QS **L51** - Lutron 5-Series *(5%, EcoSystem)* **PL2** - Philips Xitanium *(1%, 0-10v)* **PS1** - Philips Xitanium *(50%/100%)* **ND** - Non-Dimming QS *Driver pg. 4*	**1** - Single Circuit QS **M** - Multi Circuit **E** - Emergency QS *(entire fixture)* **N** - Night Light QS *(entire fixture)* *Circuiting pg. 4*	**0** - None QS **_P** - Philips Bodine 10W QS **_I** - Iota 10W QS **_IC** - Iota 10W *(CEC Listed)* **_E** - Emergency Circuit Section **_N** - Night Light Circuit Section **_L** - Life Safety Circuit Section **_G** - Philips Bodine GTD *Battery and Emergency pg. 4*	**W** - White QS **S** - Metallic Silver **BL** - Textured Black **BR** - Bronze **GR** - Graphite **CC** - Custom Color *Finish pg. 4*

_ _	
FIXTURE OPTIONS	**CONTROLS**
QS - QuickShip QS **CP** - Chicago Plenum QS **MRF** - Fixed MR16 Halogen **LMRF** - Fixed MR16 LED **RC** - Rotating Crossbar **LC** - Clear Lens **B** - Baffle **GLR** - Internal Fast Blow Fuse QS *Fixture Options pg. 5*	*Pinnacle is able to accommodate different control solutions from different manufacturers. Consult Factory for more information.*

[1]For Quickship CRI, CCT & Output see chart on page 5 [2] Individual fixtures come in 2', 3', 4', 5', 6', 8' lengths .Continuous row come in 1' increments. [3]Specify mounting for continuous length: G1, G9, GS, FL, NF & SF for continuous rows, G1G, G9G, GSG, FLF, NFN & SFS for individual lengths. [4] Enter quantity for Battery and Emergency, Example 2P.

CRI, CCT & Output

- Specify either 80 or 90 CRI
- Longer lead-time may apply for 90 CRI. Consult factory
- 80 CRI = R9≥19 and 90 CRI = R9≥61

Custom Output- Lumens OR Wattage

CL_ _ _ _ _	Specify CRI, CCT and desired lumens (i.e. CL835700)	*Specify lumens between standard offering listed below. Lumens are specified per color temp*
CW_ _ _ _ _	Specify CRI, CCT and desired wattage (i.e. CW9407)	*Specify watts between standard offering listed below*

80 CRI

	Color	Output	Watts *per foot*	Shielding **WW** Wall Wash *Lumens/ft*	*LPW*
830	3000K	Standard	6.0	329	54.6
830HO	3000K	High	10.3	511	49.7
835	3500K	Standard	6.0	343	56.9
835HO	3500K	High	10.3	534	52.0
840	4000K	Standard	6.0	352	58.4
840HO	4000K	High	10.3	548	53.3

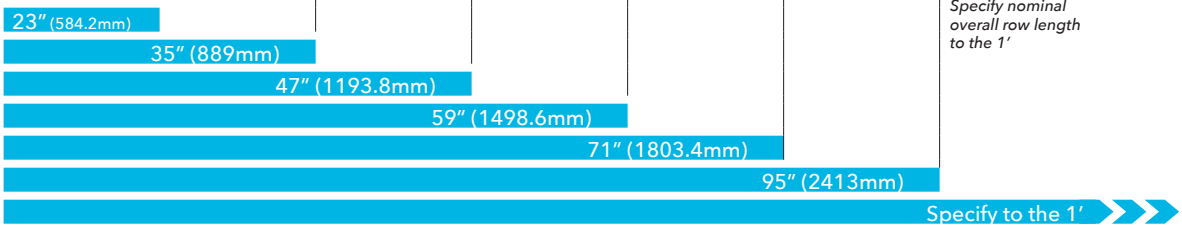
90 CRI

927	2700K	Standard	6.0	270	44.8
927HO	2700K	High	10.3	420	40.9
930	3000K	Standard	6.0	304	50.5
930HO	3000K	High	10.3	471	45.8
935	3500K	Standard	6.0	309	51.3
935HO	3500K	High	10.3	481	46.8
940	4000K	Standard	6.0	314	52.1
940HO	4000K	High	10.3	489	47.6

Length

- Individual units cannot be joined, end trims are factory installed and cannot be removed
- Continuous Rows are made up of even and odd length fixtures; designed to fall on-grid

2	**3**	**4**	**5**	**6**	**8**	**–**
Indiv. Fixture	Indiv. Fixture	Indiv. Fixture	Indiv. Fixture	Indiv. Fixture	Indiv. Fixture	Cont. Run *Specify nominal overall row length to the 1′*



Applications & Certificates

Construction: Formed cold-rolled 20 gauge steel housing. Highly reflective die-formed white painted aluminum reflector.

Shielding: Diffuse snap-in acrylic lens, removable for maintenance.

Mounting: EDGE is designed to install into acoustical grid and inaccessible ceilings. Specify GXG, FLF, SFS, NFN for individual, unjoinable units (individual units will fall on-grid). Specify GX, FL, SF, NF for continuous runs (runs designed to fall on-grid). Consult factory for detailed installation instructions. Maximum fixture weight is 15lbs per 4' fixture.

LED: 25°C test environment. Lumen output/wattage has a margin of +/- 5%; 2' or 3' lengths may have a greater wattage deviation. All luminaire configurations tested in accordance with IES LM-79. Diodes tested in accordance with IES LM-80. Lifetime calculated using IES TM-21. Minimum lifetime greater than 60,000 hours. Lifetime Projection L70 = 122,900 hours and L90 = 36,600 hours. MacAdam 3-Step Ellipses. Not all products are Lighting Facts listed. For all available IES files, please visit our website at pinnacle-ltg.com.

CRI, CCT & Lumen Output: Two lumen packages available. Standard and High (HO). Custom outputs are available. Specify custom lumens or watts between standard offering listed on CRI, CCT & Output page. 80 CRI is available for 3000K, 3500K, and 4000K. 90 CRI is available for 2700K, 3000K, 3500K, and 4000K. 80 CRI = R9≥19 and 90 CRI = R9≥61.

Voltage: Universal (U), 120 volt (1), 277 volt (2) and 347 volt (3) options available. Must specify OL3 in Driver section when 347 volt (3) is selected. Some EDGE configurations will not accommodate all voltage options; consult with factory.

Driver: Standard Driver Option is Osram 0-10V, 10% = OL1. Electronic driver, Power factor is >0.9 with a THD <20%. Driver Lifetime: 50,000 hours at 25°C ambient operating conditions. Ambient operating range: -20°F/-30°C to 96°F/35°C. For more driver options, see Pinnacle Resource Guide. Some EDGE configurations will not accommodate all driver options.

Circuiting: Select from single circuit (1), Multi circuit - For multiple circuiting and zone control, requires factory shop drawing (M), Emergency circuit (E), Life Safety (L) or Night Light circuit (N). For emergency circuiting situations that require no through wire or circuit separation, Life Safety Circuit should be selected. This will provide a separate power feed and only the Life Safety Circuit in that section. Some EDGE configurations will not accommodate all circuiting options; consult with factory.

Battery & Emergency: Select battery or emergency options if required. If battery or emergency option is not required, enter 0. Battery duration is 90 minutes as standard. Test button is remote to fixture. For more Battery options, see Pinnacle Resource Guide.

Finish: Standard powder-coat textured white, metallic silver, textured black, graphite or bronze painted finish; consult factory for chip of standard paint finishes or for additional custom color and finish options.

MR16: Ideal for conference rooms, corridors, wall washing, retail spaces and training facilities where accent lighting is required. Fully enclosed compartment eliminates light from entering into our fixture areas. For LED and Halogen lamps (lamps are not included). Consult factory for other lamp types. Standard 60 watt max LED electronic transformer (120v or 277v), 50 watt max halogen lamp transformer (120v or 277v), MR16 installed as an independent circuit. MR16 to match fixture voltage. 277v dimmer must be sourced. Consult factory for MR16 configurations. Pinnacle's MR16 applications are to be used with Soraa lamps with a maximum of 13 transformers on one circuit.

Controls: Specify PD for daylight sensor, requires 0-10v driver. Some EDGE configurations will not accommodate all control options; consult with factory.

Labels: UL and cUL Listed. Standard and HO lumen packages are IC Rated, approved for dry/damp location unless otherwise noted.

Fixture Weight: Maximum fixture weight is 15lbs per 4' fixture.

Buy American Act Compliant

Warranty: EDGE LED offered with a 5-year limited warranty. Covers LED, driver and fixture.

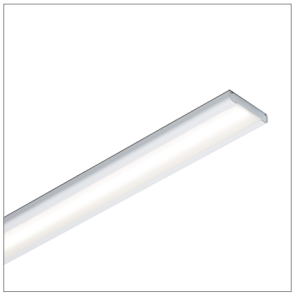
vode Adaptive architectural lighting systems

Spec Guide

ZipTwo® | Micro Profile | 707

Direct lighting for open office, wall wash and grazing applications.

CG1 Options



120° Symmetric lens, white

(D4)

Diffuse with microbaffle

CG2 at Stacks

(S2)

60° Symmetric

Benefits & Features

Micro Profile, Robust Design
Flat profile. 0.36" (9mm) x 1.38" (35mm).

Superior Light Quality & Performance
Output up to 1575 lm/ft (5168 lm/m) (HO), 161 lm/W (HO). 80 or 90 CRI & tunable white (2200K-6500K) available.

Versatile Mounting Options, Easy Installation
Magnet with tape-on metal strip or low profile clip allow for mounting to almost any surface or T-Bar ceiling.

Better Optics & Beam Control
Options of Diffuse, 120°, 60°, 40° and 85° (asymmetric) lens for general illumination, grazing or wall wash. Excellent glare control with optical film and MicroBaffle™.

40° Symmetric lens, black

Build Your Specification

707-Z2	SL				0

System & Rail Type
707-Z2 ZipTwo

System Type
SL Standard Linear

System Length
Specify overall system length in ft/in or M/mm.

Rail Length
24 24" (610mm)
36 36" (914mm)
48 48" (1219mm)
60 60" (1524mm)
72 72" (1829mm)
96 96" (2438mm)
ZZ Other rail length or layout (please specify)

Mounting
C Clip
CM Clip with Micro J-Box
T Magnet with Tape-On Metal Strip
T1 9/16" T-Bar Clip, low profile
T2 15/16" T-Bar Clip, low profile
T3 15/16" T-Bar Clip, medium profile
T4 15/16" T-Bar Clip, concealed
T5 9/16" T-Bar Clip, medium profile
T6 Slotted T-Bar Clip
T7 Dimensional T-Bar Clip
SC Strut Channel Clip
ZZ Other (please specify)

Arm/Cord Length
0 None

RP				Z

Power Location
Remote Power

RP25 25' (7.62m) Wire Harness
RP50 50' (15.24m) Wire Harness
RP75 75' (22.86m) Wire Harness
RP100 100' (30.48m) Wire Harness

Power Type
Flexible 1 to 1 Power

AE eldoLED 0-10v, 1.0% Dimming
AT eldoLED 0-10v, 0.1% Dimming
AD eldoLED DALI, 0.1% Dimming
AX eldoLED DMX, 100-0% Dimming
AH Hi-lume 1% EcoSystem, Soft On / Fade to Black Technology, LDE1
AH2 Hi-lume 1% 2-wire LTEA2W (120V forward phase only)

Optomized Power

AEO eldoLED 0-10v, 1.0% Dimming
ATO eldoLED 0-10v, 0.1% Dimming
ADO eldoLED DALI, 0.1% Dimming
AXO eldoLED DMX,100-0% dimming

ZZ Other (please specify)

See **Power Guide for driver features & limitations.*

Voltage
1 120v
2 120v-277v
X Not Yet Specified

Emergency Power
0 No Emergency Power
ZZ Emergency Power *(specify requirements)*

LED Type
Z Zipper Board™

Lumen Output
LO Low Output
SO Standard Output
HO High Output*
ZZ Other (please specify)

*See **IES Files** page for details.*
See **Powerr Guide for driver features & limitations.*

Color Temperature
80+ CRI

27 2700K
30 3000K
35 3500K
40 4000K

90+ CRI

279 2700K
309 3000K
359 3500K
409 4000K

ZZ Other (please specify)

Optics
A1 85° Asymmetric
S1 40° Symmetric
S2 60° Symmetric
S3 120° Symmetric
D3 Diffuse[1]
D4 Diffuse with MicroBaffle[1]

Sensors
0 None
ZZ Other (please specify)[2]

Finish
WH White
BL Black

Options
0 None
9 9' 18/3 Cord and Plug

NOTES & LIMITATIONS

[1] *Diffuse (D3) and Diffuse with MicroBaffle (D4) are only available in White Finish (WH).*
[2] *Sensors are available please contact Vode for more information.*

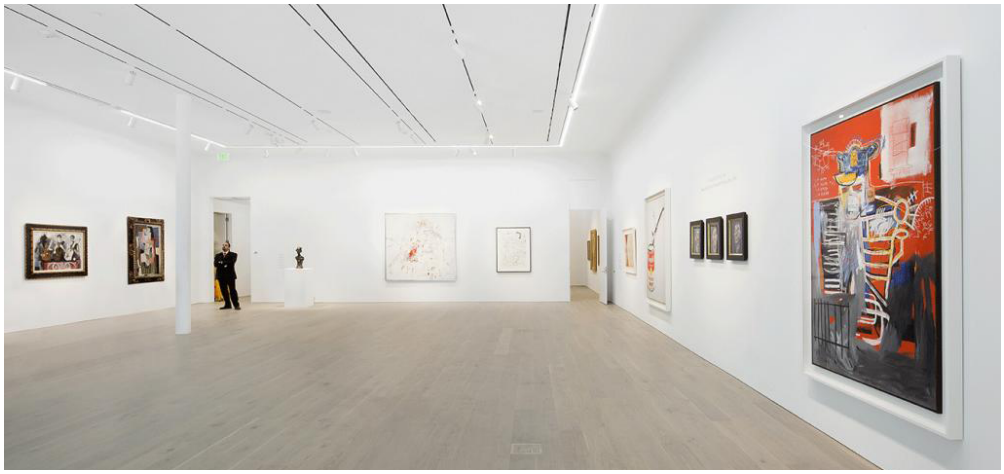
*5 Year Limited Warranty. See full Vode warranty description **here** or at vode.com.*

Listed to UL standards for damp location by a Nationally Recognized Testing Laboratory (NRTL) recognized by OSHA.

Applications

General Interiors and Offices

Paul Hastings, Los Angeles, CA



Christie's Auction House, Los Angeles, CA

Booz Allen Hamilton, Washington, DC

Applications

General Interiors and Offices

Tuck Hinton Architects, Nashville, TN

Forbes Media, San Francisco, CA

Structure

Rail Lengths	24” (610mm), 36” (914mm), 48” (1219mm), 60” (1524mm), 72” (1829mm), 96” (2438mm).
Rail Dimensions	0.36” (9mm) x 1.38” (35mm). See dimensions section for details
Construction	Extruded and machined 6063 aluminum.
Mounting	Clip, Clip with Micro J-Box, Magnet with Tape-On Metal Strip, T-Bar Clips for most grid/panel construction, Strut Channel Clip.
Run Length	24” (610mm) minimum. Rail lengths may be installed end-to-end to any length.
Operating Temperature	32°F to 104°F (0°C to 40°C).
Humidity	0-95%, non-condensing. Suitable for damp locations.
System Weight	0.15lbs per ft (0.07kg per 305mm). *Power supply and housing not included.*

Materials

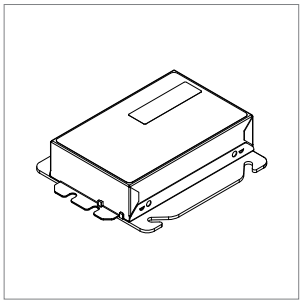
LED Board Construction	Aluminum core PCB, black LCP connectors, RoHS compliant.
Lens	High-impact extruded acrylic glass (PMMA).
Power Cable	Ø3mm, 33/2 AWG, Plenum (CMP) rated semi-rigid PVC or FEP, flame tested UL-910 *(PVC free in 2020)*
Cable Connectors	Unfilled black nylon, rated UL 94 V-0, halogen free, PVC or FEP overmold, RoHS compliant *(PVC free in 2020)*
Remote Linear Power Housing (RLP)	20.7” x 2.375” x 2.53”, 0.054” formed Galvanized Steel
Remote Brick Power Housing (RBP)	4.32” x 3.37” x .078” Galvanized Steel mounting plate

Power and Controls

Power Type	Class 2 (<60v output) constant current driver
Dimming Controls	Dimming (0.1%, 1%), 0-10v, DALI, DMX, Lutron Hi-lume 1% are available. *See **Power Guide** for details.*
Input Voltage	120v - 277v, 50/60hz
Power Location	Remote power. Maximum remote distance up to 100’ (30.5m) *depending* on driver selection. *See **Power Guide** for details.*

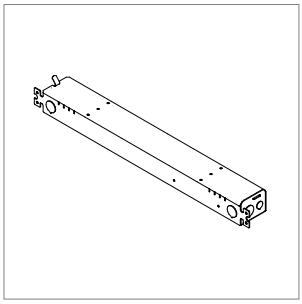
Remote power is locating the power supply away from the fixture. Remote power comes in two housing styles: brick style and linear style. Consult ***Power Guide*** to determine which type you will receive.

Remote Brick Power Housing



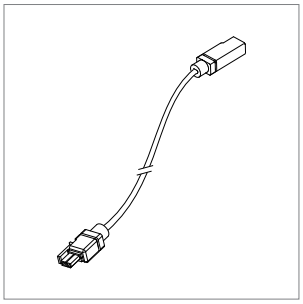
Supplied for some remote power applications. One remote power supply housing is supplied for each rail. Provided driver mounting plate fits standard 4” metal, square J-Boxes with a minimum volume of 21 in^3 (J-Box not provided).
See ***Tech Sheet*** for details.

Remote Linear Power Housing



One remote power supply housing is supplied with each power supply. All Vode linear remote drivers come in a 0.054” (0.8mm) formed galvanized steel power supply housing with five (5) knockouts: (4) 1-1/8”, (1) 7/8“ and (1) 9/16”. Accommodates standard linear power supplies.
See ***Tech Sheet*** for details.

Wire Harness

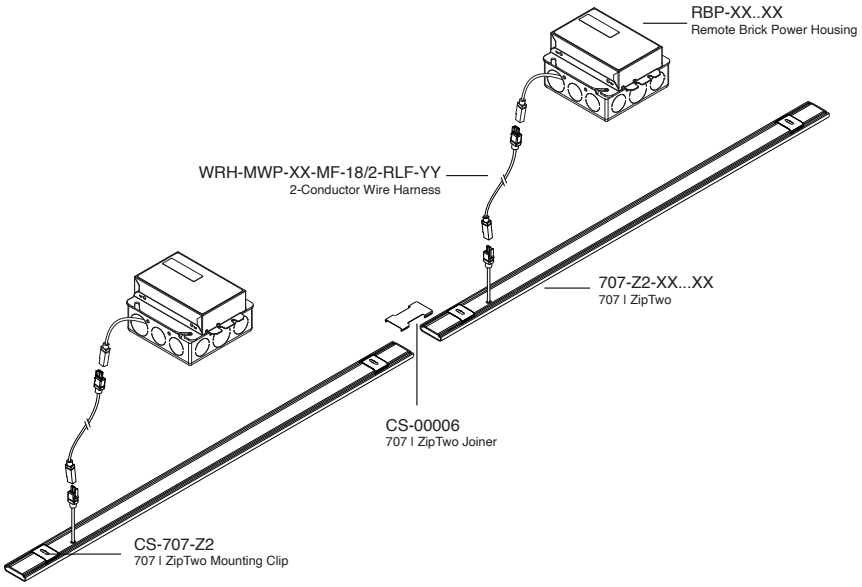


Wire harness connects driver to rail. Wire hareness is 25’ (7.6m) with micro fit molex connectors for quick and easy installation. Multiple harnesses can be combined for a total length of up to 100’ (30.5m).
See ***Tech Sheet*** for details.

Power and Controls

Flexible 1 to 1 power

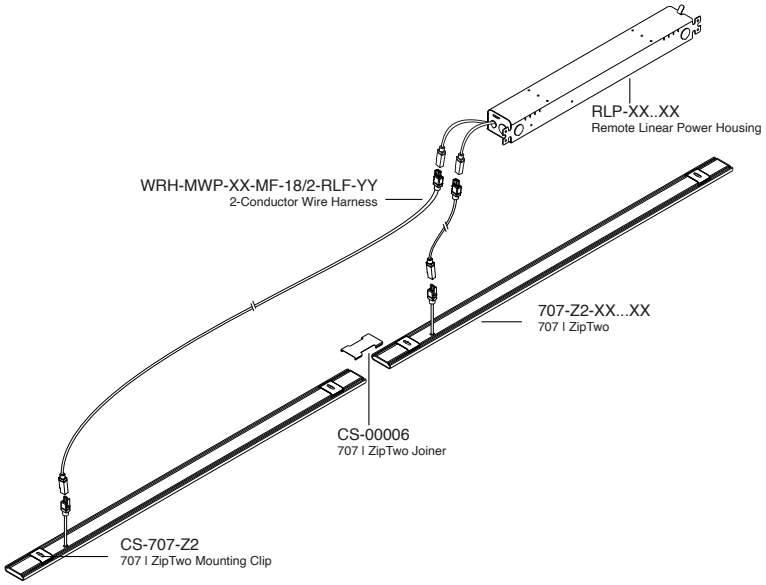
For Flexible 1 to 1 Power, Vode supplies one single output driver per fixture, allowing each fixture to be controlled independently. Direct/Indirect fixtures are supplied with two single output drivers, allowing the direct and indirect lighting to be controlled independently. Consult ***Power Guide*** to determine which type you will receive.



Optimized Power

To optimize power, Vode configures specifications with drivers that have 2 or 4 outputs. Depending on system configurations and power requirements, up to 4 fixtures can be powered from a 4-output driver. Consult ***Power Guide*** to determine which type you will receive.

IMPORTANT: Each fixture will still require individual wire harnesses, as shown below.

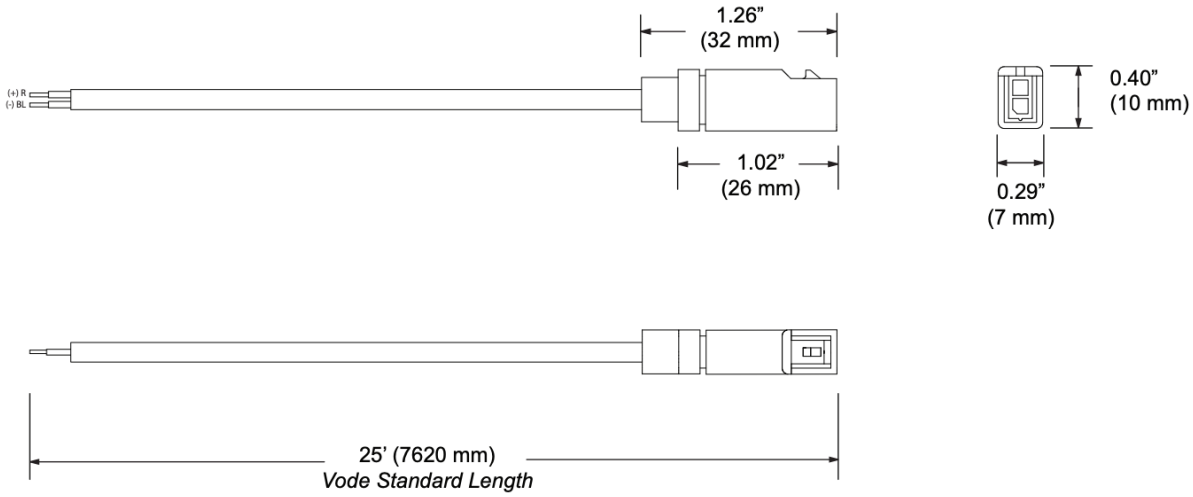


Note: Drawings not to scale, for reference only.

Power and Controls

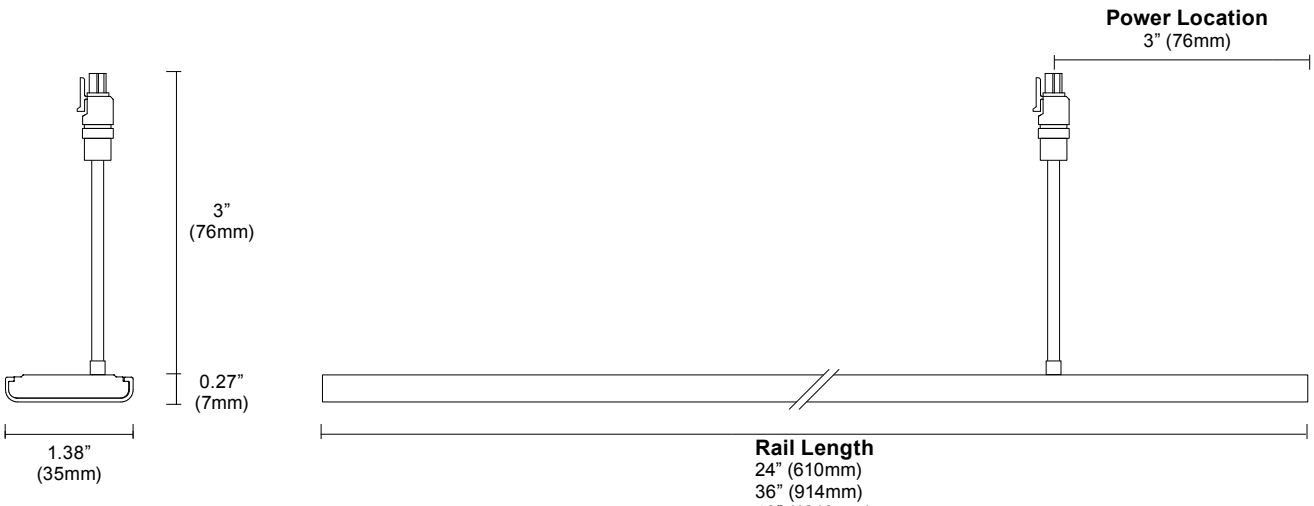
Wire Harness

Low voltage wire harness connects driver to rail. Wire hareness is 25’ (7.6m) 18/2 AWG stranded wire with provided micro fit molex connectors on either end for quick and easy installation. Multiple haresses can be combined for a total length of up to 100’ (30.5m). Refer to Vode Power Guide for max remote distance based on power selection. Consult ***Power Guide*** to determine which type you will receive.



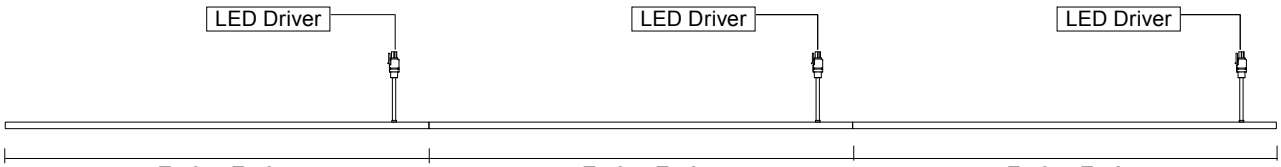
Note: Drawings not to scale, for reference only.

Dimensions



Rail Length
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

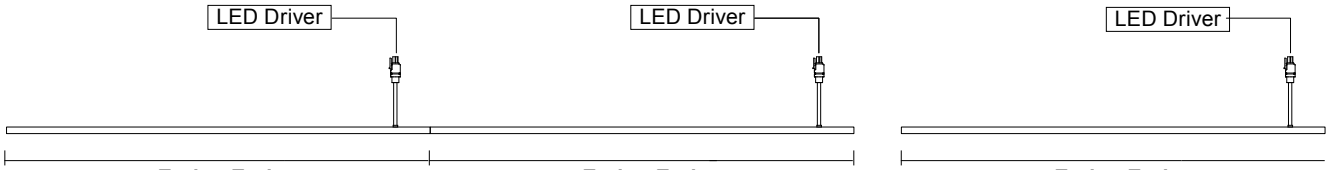
Layout



End to End
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

End to End
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

End to End
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

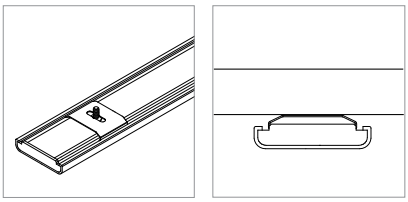


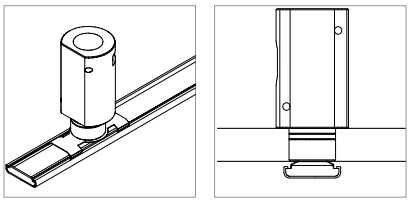
End to End
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

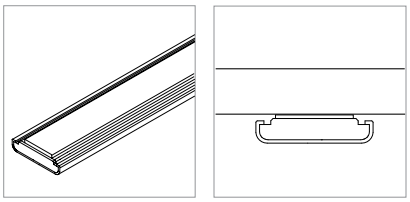
End to End
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

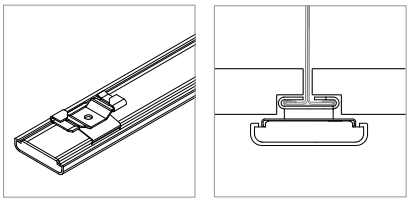
End to End
24” (610mm)
36” (914mm)
48” (1219mm)
60” (1524mm)
72” (1829mm)
96” (2438mm)

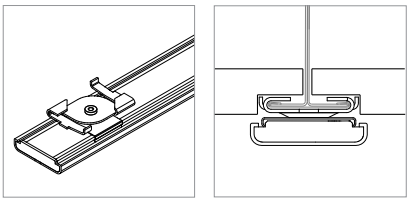
Mounting Options

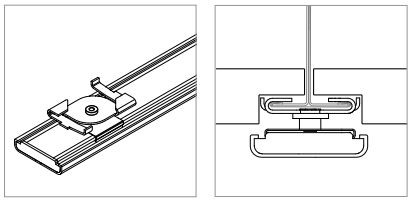

Clip (C)

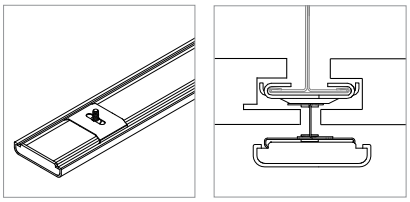

Clip with Micro J-Box (CM)

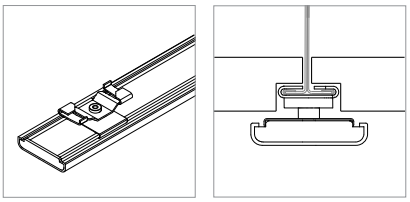

Magnet with Tape-On Metal Strip (T)

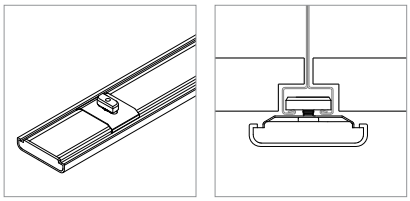

9/16" T-Bar Clip, low profile (T1)

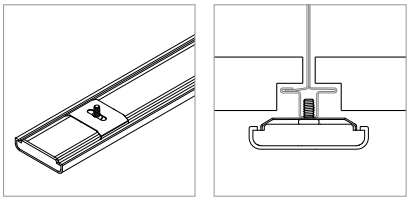

15/16" T-Bar Clip, low profile (T2)

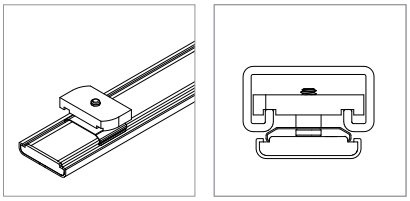

15/16" T-Bar Clip, medium profile (T3)


15/16" T-Bar Clip, concealed (T4)


9/16" T-Bar Clip, medium profile (T5)


Slotted T-Bar Clip (T6)


Dimensional T-Bar Clip (T7)

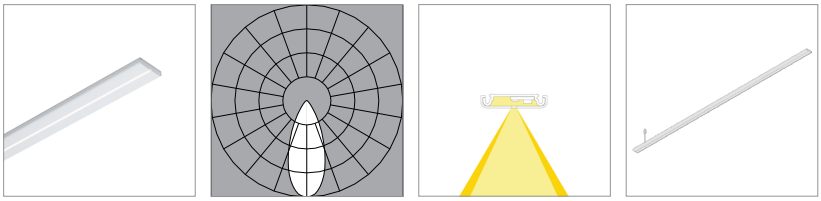

Strut Channel Clip (SC)

See ***ZipTwo Clip Guide*** to check compatibility.

Performance | Zipper LED

Zipper Board has 72 diodes per foot (305mm). Testing based on a 4' rail section. Lumen measurement complies with IES-LM-79-08 testing procedures.

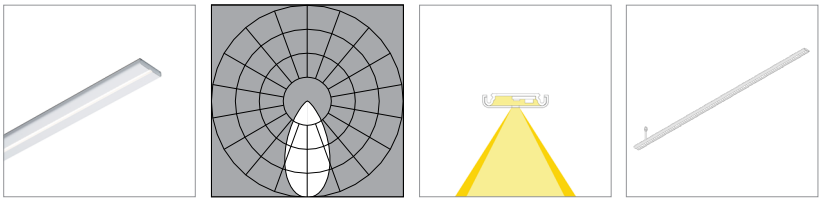
40° Symmetric, white finish (S1-WH)



L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	52	54	55	55	45	47	48	48
Lumens per foot (305mm)	193	199	203	203	167	172	175	177
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	4	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	60	62	63	63	52	53	54	55
Lumens per foot (305mm)	386	399	407	407	333	344	351	354
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	59	61	62	62	51	53	54	54
Lumens per foot (305mm)	580	598	610	610	500	515	526	531
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

60° Symmetric, white finish (S2-WH)



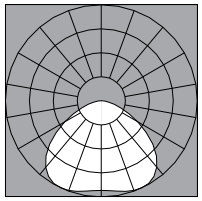
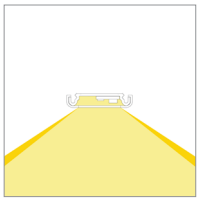
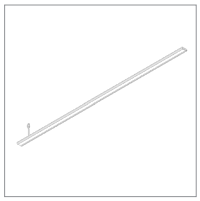
L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	80	83	84	84	69	71	73	74
Lumens per foot (305mm)	297	306	312	312	256	264	269	272
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	91	94	96	96	79	81	83	84
Lumens per foot (305mm)	594	612	625	625	512	528	539	544
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	91	93	95	95	78	81	82	83
Lumens per foot (305mm)	890	919	937	937	768	792	808	816
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

Performance | Zipper LED Continued

Zipper Board has 72 diodes per foot (305mm). Testing based on a 4' rail section. Lumen measurement complies with IES-LM-79-08 testing procedures.

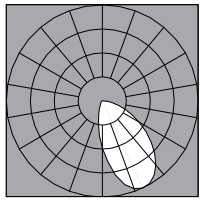
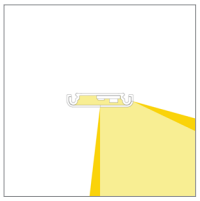
120° Symmetric, white finish (S3-WH)

L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	115	119	121	121	99	103	105	106
Lumens per foot (305mm)	427	441	450	450	368	380	388	391
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	130	134	137	137	113	117	119	121
Lumens per foot (305mm)	854	881	899	899	736	760	775	783
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	130	134	137	137	112	116	118	119
Lumens per foot (305mm)	1281	1322	1349	1349	1105	1139	1163	1174
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

85° Asymmetric, white finish (A1-WH)

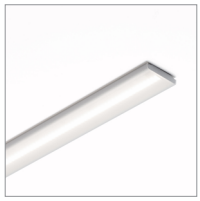
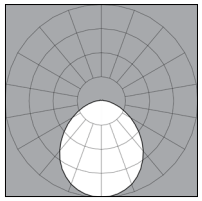
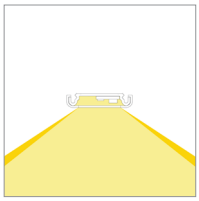
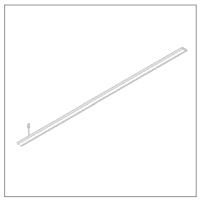

L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	64	66	67	67	55	57	58	58
Lumens per foot (305mm)	236	243	248	248	203	209	214	216
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	73	75	76	76	63	65	66	67
Lumens per foot (305mm)	471	486	496	496	406	419	427	432
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.5	6.5	6.5	6.5
High Output (HO)								
Efficacy - Lumens per Watt	72	74	76	76	62	64	65	66
Lumens per foot (305mm)	707	729	744	744	609	628	641	648
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

Performance | Zipper LED Continued

Zipper Board has 72 diodes per foot (305mm). Testing based on a 4' rail section. Lumen measurement complies with IES-LM-79-08 testing procedures.

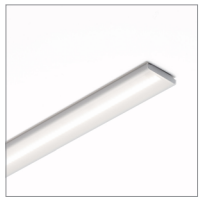
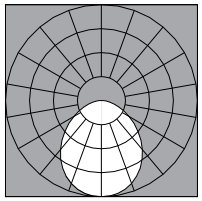
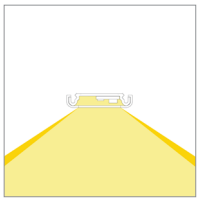
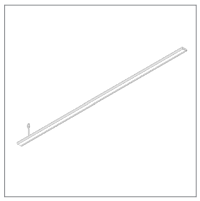
Diffuse, white finish (D3-WH)

L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	130	134	137	137	112	115	118	119
Lumens per foot (305mm)	481	496	506	506	415	428	437	441
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	148	153	157	156	127	131	134	135
Lumens per foot (305mm)	962	993	1013	1013	829	856	873	882
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	146	151	154	154	126	130	133	134
Lumens per foot (305mm)	1443	1489	1519	1519	1244	1284	1310	1323
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

Diffuse with MicroBaffle, white finish (D4-WH)

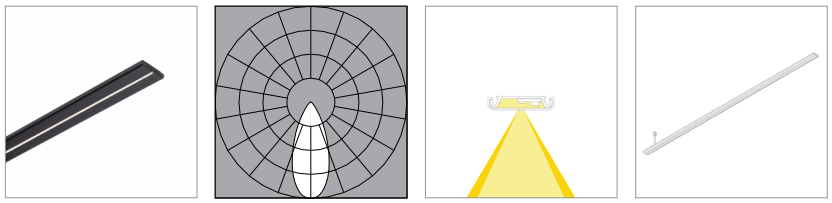
L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	116	119	122	122	100	103	105	106
Lumens per foot (305mm)	428	442	451	451	369	381	389	393
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	132	136	139	139	114	117	120	121
Lumens per foot (305mm)	857	884	902	902	739	762	777	785
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	130	135	137	137	113	116	118	120
Lumens per foot (305mm)	1285	1326	1353	1353	1108	1143	1166	1178
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

Performance | Zipper LED Continued

Zipper Board has 72 diodes per foot (305mm). Testing based on a 4' rail section. Lumen measurement complies with IES-LM-79-08 testing procedures.

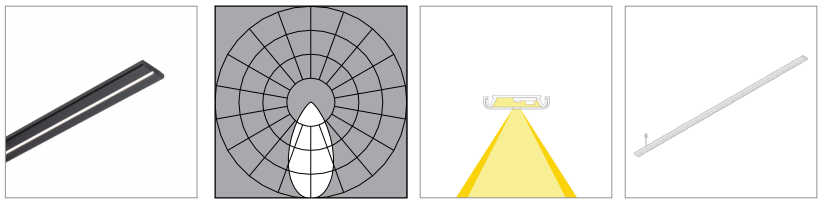
40° Symmetric, black finish (S1-BL)



L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	38	39	40	40	33	34	34	35
Lumens per foot (305mm)	139	143	146	146	120	123	126	127
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	43	44	45	45	37	38	39	39
Lumens per foot (305mm)	278	286	292	292	239	247	252	254
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
CRI								
High Output (HO)								
Efficacy - Lumens per Watt	43	44	45	45	37	38	39	39
Lumens per foot (305mm)	416	429	438	438	359	370	378	382
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
CRI								

60° Symmetric, black finish (S2-BL)



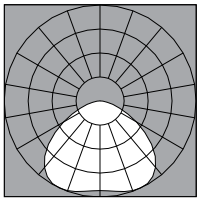
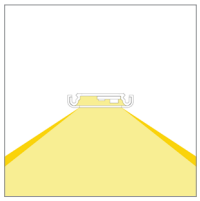
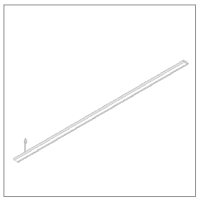
L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	54	55	56	56	46	48	49	49
Lumens per foot (305mm)	198	204	208	208	171	176	180	181
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	61	63	64	64	53	55	56	56
Lumens per foot (305mm)	396	408	417	417	341	352	359	363
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.5	6.5	6.5	6.5
High Output (HO)								
Efficacy - Lumens per Watt	61	62	64	64	52	54	55	56
Lumens per foot (305mm)	594	613	625	625	512	528	539	544
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

Performance | Zipper LED Continued

Zipper Board has 72 diodes per foot (305mm). Testing based on a 4' rail section. Lumen measurement complies with IES-LM-79-08 testing procedures.

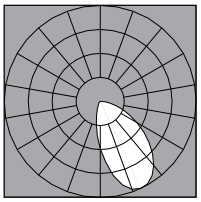
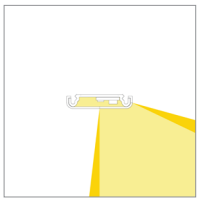
120° Symmetric, black finish (S3-BL)

L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	112	115	118	118	88	91	93	94
Lumens per foot (305mm)	414	428	436	436	357	369	376	380
Watts per foot (305mm)	3.8	3.8	3.8	3.8	4.1	4.1	4.1	4.1
Standard Output (SO)								
Efficacy - Lumens per Watt	128	132	134	134	110	113	116	117
Lumens per foot (305mm)	829	855	873	873	715	737	752	760
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	126	130	133	133	109	112	115	116
Lumens per foot (305mm)	1243	1283	1309	1309	1072	1106	1128	1140
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

85° Asymmetric, black finish (A1-BL)


L80 >60,000 hours

	80 CRI (80min., 84 avg.)				**90 CRI** (90min., 96 avg.)			
Low Output (LO)	2700K	3000K	3500K	4000K	2700K	3000K	3500K	4000K
Efficacy - Lumens per Watt	36	37	38	38	31	32	32	33
Lumens per foot (305mm)	131	135	138	138	113	116	119	120
Watts per foot (305mm)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Standard Output (SO)								
Efficacy - Lumens per Watt	41	42	43	43	35	36	37	37
Lumens per foot (305mm)	262	270	276	276	226	233	238	240
Watts per foot (305mm)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
High Output (HO)								
Efficacy - Lumens per Watt	40	42	42	42	35	36	37	37
Lumens per foot (305mm)	393	405	414	414	339	349	357	360
Watts per foot (305mm)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9

gotham® | EVO®

Multiple Layers of Light

Luminaire **CH**
Surface downlight

General Illumination Surface Ceiling Cylinder 4"

Feature Set

- Batwing distribution with feathered edges provides even illumination on horizontal and vertical surfaces
- Bounding Ray™ optical design
- 45° Cutoff to source and source image
- Fully serviceable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- Fixtures are damp location standard; wet location option (WL), covered ceiling
- 20 standard colors in textured and gloss finish; custom or RAL colors also available
- Field configurable surface junction box conduit covers available
- ENERGY STAR® Certified product

Distribution

Superior Perfomance

Nominal Lumens	250	500	750	1000	1500	2000	2500	3000	3500	4000	4500	5000
Delivered Lumens	271	573	808	1001	1527	1994	2580	3110	3612	4120	4584	5045
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7	31.2	38.4	35.4	40.1	44.7
Lumens per Watt	87.4	79.6	102.3	113.8	111.5	102.3	100.4	99.7	94.1	116	114	113

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Healthcare

Special Applications

OVERVIEW

COMPLIMENTARY PRODUCTS

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

EXAMPLE: EV04SC 35/15 AR MWD LSS MVOLT EZ1 JBXCC DWHG

Series		Color Temperature		Lumens		Reflector Color		Distribution		Reflector Finish		Voltage	
EV04SC	EVO 4in Surface Ceiling Round Cylinder Open Downlight	**27/**	2700 K	**02**	250 lumens	**AR**	Clear	**MD**	Medium (0.9 s/mh)	**LSS**	Semi-specular	**MVOLT**	120V - 277V
		30/	3000 K	**05**	500 lumens	**PR**	Pewter	**MWD**	Medium wide (1.0 s/mh)	**LD**	Matte diffuse	**120**	120V
		35/	3500 K	**07**	750 lumens	**WTR**	Wheat	**WD**	Wide (1.2 s/mh)	**LS**	Specular	**277**	277V
		40/	4000 K	**10**	1000 lumens	**GR**	Gold					**347**[2]	347V
		50/	5000 K	**15**	1500 lumens	**WR**[1]	White painted						
				20	2000 lumens	**BR**[1]	Black						
				25	2500 lumens	**WRAMF**[1]	White Anti-microbial						
				30	3000 lumens	**BZR**[1]	Dark Bronze painted						
				35	3500 lumens								
				40	4000 lumens								
				45	4500 lumens								
				50	5000 lumens								

Driver[3]		Mounting		Control Interface[6]	
GZ10	0-10V driver dims to 10%	**JBX**	Integral driver, Recessed or Surface J-box	**(blank)**	No controls
GZ1	0-10V driver dims to 1%	**JBXCC**	Integral driver, Surface J-box with Conduit Covers	**NLT**	nLight® dimming pack.
EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.			**NLTER**[7]	nLight® dimming pack for fixtures on emergency circuit
EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.			**NLTAIR2**	nLight® AIR dimming pack.
EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.			**NLTAIRER2**[7]	nLight® AIR dimming pack for fixtures on emergency circuit
EDAB[5]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.				
EDXB[4,5]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. Min: 1000LM; Max: 4000LM.				
ECOS2[5,6,7]	Lutron® Hi-Lume® 2-wire forward-phase driver. 120V Only. Minimum dimming level 1%. Min: 1000LM; Max: 2500LM.				
ECOD[5,8]	Lutron® EcoSystem® digital Hi-Lume 1% soft-on, fade to black. Min: 250LLM; Max: 1000LM.				

Options		Architectural Colors - Powder Paint[10]			
SF	Single fuse. Specify 120V or 277V.	**DDB**	Gloss Dark Bronze	**DDBT**	Textured Dark Bronze
90CRI	High CRI (90+)	**DBL**	Gloss Black	**DBLB**	Matte Black
N80	nLight Lumen Compensation	**DWH**	Gloss White	**DWHG**	Textured White
HAO[9]	High Ambient Option (40°C)	**DMB**	Gloss Medium Bronze	**DBNH**	Textured Bronze
WL[8]	Wet Location	**DNA**	Gloss Natural Aluminum	**DNAT**	Textured Natural Aluminum
		DSS	Gloss Sandstone	**DSST**	Textured Sandstone
		DGC	Gloss Charcoal Grey	**DSPD**	Textured Dark Grey
		DTG	Gloss Tennis Green	**DSPE**	Textured Green
		DBR	Gloss Bright Red	**DSPH**	Textured Light Red
		DSB	Gloss Steel Blue	**DWHAMF**	Gloss White with Anti-microbial finish

ACCESSORIES —order as separate catalog numbers (shipped separately)

CYLJBOXADPT 4SQ2OCT __ 4in Square J-box to 4in Octagonal J-box adaptor. Replace __ with Architectural Color or PRM for primed ready for field painting

ORDERING NOTES

1. Not Available with Finishes.
2. Factory supplied step down transformer must be remote mounted. Access required to device.
3. Refer to Tech 240 for compatible dimmers.
4. Includes terminator resistor.
5. Not Available with Control Interfaces.
6. Field installed. Access required to location of remote mounted device.
7. For use with generator supply EM power. Will require an emergency hot feed and normal hot feed.
8. Not available with JBXCC. Max: 3000LM.
9. Only available up to 2500 lumens; not available with wet location or ECOS2.
10. For details on RAL and Custom colors please see Architectural colors.

SPECIFICATIONS

Optical Assembly
Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Optical design is a Bounding Ray™ design with 45° cutoff to source and source image. Top down flash characteristic for superior glare control.

Electrical
The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. Support 347V via remote-mounted stepdown transformer. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum solid copper.

Controls
Luminaire shall be equipped with interface for nLight wired or nLight AIR networks with integral power supply as per specification.

Emergency
Luminaires supplied with a battery pack comply with NFPA 101 (Life Safety code) and deliver constant light output throughout the 90 minutes of code required emergency operation period when there is a normal AC power loss.

Luminaires equipped with a generator transfer device work in conjunction with an auxiliary generator or a central inverter system to power fixtures for safe egress lighting.

Dimming
The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction
Heaving-gauge aluminum construction.

Extruded body with flangeless reflector allows flow-through passive thermal management.

Surface ceiling mount for direct installation to 4" recessed or surface octagonal or square junction box.

Optional field configurable conduit covers available. Conduit covers match cylinder in finish and diameter.

Recessed gear box available for driver above ceiling, nLight, or battery pack options.

Listings
Fixtures are CSA Certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL, damp location standard; wet location covered ceiling optional (WL).

Luminaire configurations are Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization. Visit www.energystar.gov for specific configurations listed.

Photometrics
LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by the center of the quadrangles defined in ANSI C78.377-2015.

Warranty
5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:
Actual performance may differ as a result of end user environment and application.
All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire
This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

EVO - eldoLED Driver Default Dimming Curve			
Nomenclature	Min Dimming	Driver Dim Curve	Control Dim Curve
EZ10	10%	Linear	Linear/Logarithmic
EZ1	1%	Linear	Linear/Logarithmic
EZB	<1%	Logarithmic	Linear
EDAB	<1%	Logarithmic*	Linear
EDXB	<1%	Square	Linear

*Changable thorugh DALI controller

Lumen Output Multiplier		
CRI	CCT	Multplier
80	2700K	0.916
	3000K	0.948
	3500K	1
	4000K	1.032
	5000K	1.1
90	2700K	0.748
	3000K	0.8
	3500K	0.838
	4000K	0.845
	5000K	0.945

Reflector Finish Multiplier	
Reflector Finish	Multiplier
LS - Specular	1
LSS - Semi Specular	0.956
WR - White	0.87
LD - Matte Diffuse	0.85
BR - Black	0.73
BZR - Bronze	0.73

Distributions		
Nomenclature	Beam Angle	Field Angle
MD	54	82
MWD	67	89
WD	71	92

Driver		Control Provided (note: 347V/UVOLT versions provided with 347 option selected)			
Nomenclature	Description	NLT	NLTER	NLTAIR2	NLTAIRER2
GZ10	0-10V driver dims to 10%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
GZ1	0-10V driver dims to 1%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ10	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ1	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZB	eldoLED 0-10V SOLOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2

J-box Compatibility Matrix		Cylinder Configurations		
		JBX	JBX w/EDXB Driver	JBXCC
Recommended J-box (by others)	4" Octagonal 4x4x1.5 deep"	✓	✗	✓
	4" Octagonal 4x4x2.125 deep	✓	✓	✗
	4" Square 4x4x1.5 deep	✓ *with adaptor plate accessory	✗	✗

Standard Architectural Color Options for Cylinder Bodies

DSS P12
LITHONIA
Sandstone

DSST P90
TEXTURED
Sandstone

DBR P34
LITHONIA
Bright Red

DSPH P80
TEXTURED
Light Red

DMB P11
LITHONIA
Medium Bronze

DBNH P74
TEXTURED
Bronze

DTG P33
LITHONIA
Tennis Green

DSPE P78
TEXTURED
Green

DSB P49
LITHONIA
Steel Blue

DNA P07
LITHONIA
Natural Aluminum

DNAT P89
TEXTURED
Natural Aluminum

DGC P32
LITHONIA
Charcoal Gray

DSPD P77
TEXTURED
Dark Grey

DDB P50
LITHONIA
Dark Bronze

DDBT P88
TEXTURED
Dark Bronze

DBL P13
LITHONIA
Black

DBLB P75
TEXTURED
Black

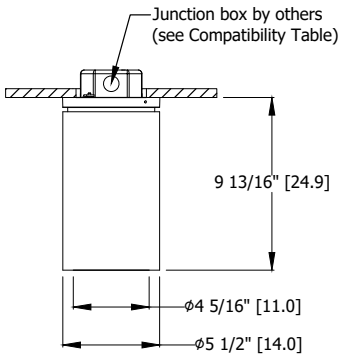
DWH P21
LITHONIA
White

DWHG P86
TEXTURED
White

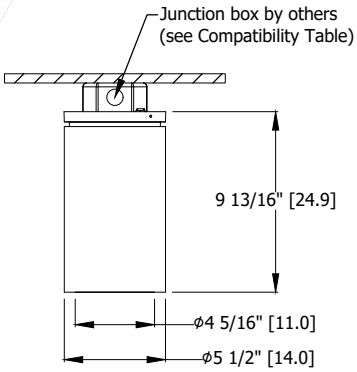
NOTE: These colors were carefully reproduced to give as true a depiction as possible of finished product color. Some colors, however, may vary slightly from actual appearance due to display/printing variations and limitations. Please always contact a Gotham representative for an accurate paint chip sample.

DIMENSIONAL DATA

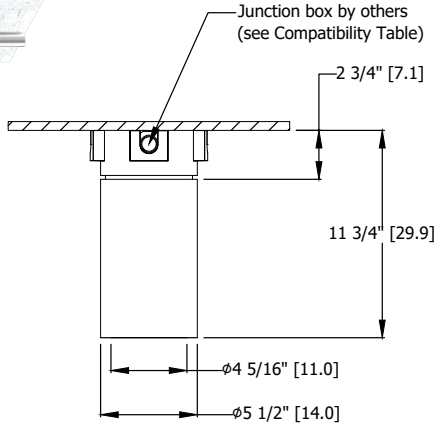
JBX Recessed J-Box



JBX Surface J-Box

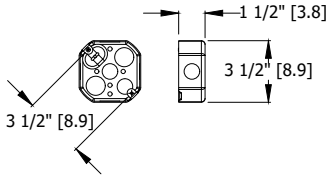


JBXCC Surface J-Box with Conduit Covers

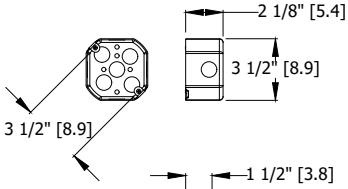


Junction Box Dimensions (by others)

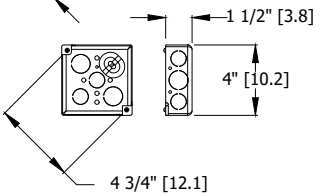
4" Octagonal J-Box, 1 1/2" Deep



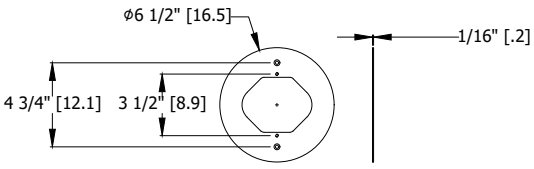
4" Octagonal J-Box, 2 1/8" Deep



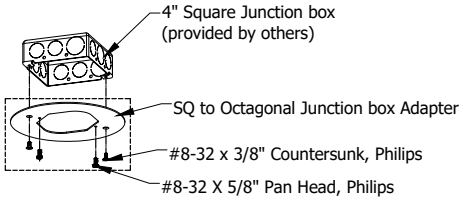
4" Square J-Box, 1 1/2" Deep

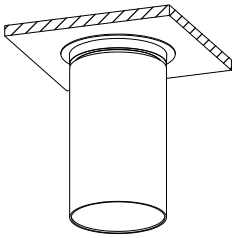


Cylinder Adapter Plate



Includes 2 mounting screws

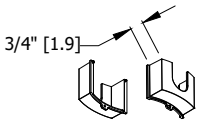




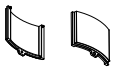
*Dimensions in inches [centimeters]

DIMENSIONAL DATA

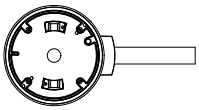
Conduit Feed Examples and Keys



Conduit Key
(4) provided with each,
for use with 1/2" or 3/4" conduit

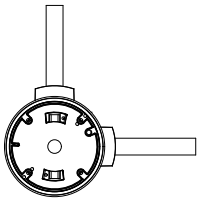


Blank Key
(4) provided with each

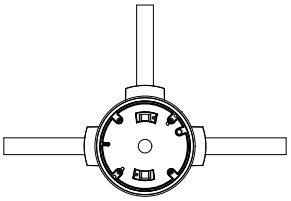


Single Conduit Feed

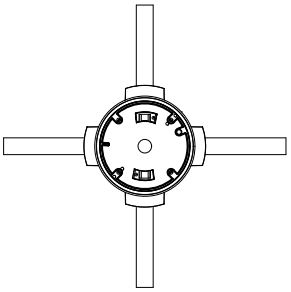
Double 180° conduit



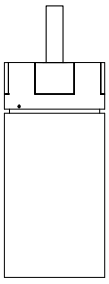
Double 90°conduit



Triple 0°, 90° & 180° conduit

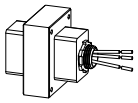


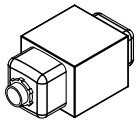
Quad 0°, 90°, 180°, & 270° conduit

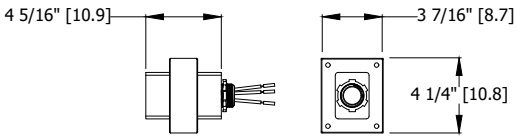


Top conduit feed

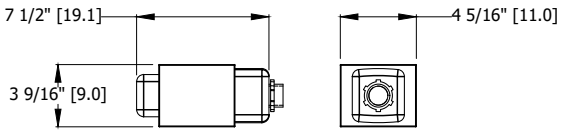
347V Stepdown Transformer







347 Transformer:
Up to 6000LM
Install to accessible
junction box by others



347 Transformer:
8000LM and up
Install to accessible
junction box by others

*Dimensions in inches [centimeters]

EVENLITE
LIFE SAFETY LIGHTING SOLUTIONS

Exit Sign **EX**
Option 1 - Clear

SOVEREIGN - LED Exit Signs

Architectural Edgelit - Flat Trim

EYE APPEAL

Sovereign LED edgelit exit signs set the standard for architectural appeal; always enhancing their surroundings and pleasing even the most discerning eye.

Subtle lines and soft curves create a distinctive "floating" edgelit look. Quality construction includes precision die cast aluminum housings with a unique, crystal clear, laser-formed thin acrylic legend.

The Sovereign has been designed with the latest high efficiency LED light sources to provide vivid pronouncement of its exit legend with exceptional uniformity and luminance levels – 4X the UL requirement.

Engineered for reliability and ease of installation, Sovereign comes in many cost-effective configurations offering superlative quality, performance, and aesthetics.

Construction

- Contoured crystal clear laser formed edgelit lens
- Lens Panel is "Last-to-Assemble" snap-in for versatility and ease of installation
- Full size universal, self-adhesive Chevron arrows with template enable on-site configuration
- Available with a range of information signage or custom graphics to order
- Custom legends with white LED light source available to order
- Precision pressure die cast aluminum legend holder, trim and surface mount housing
- Quality brushed aluminum sealed finish is standard, optional White, Black, brushed painted Brass finishes available.
- Consult factory for custom finishes.
- Hinged retaining springs eliminate exposed mounting hardware on recessed model
- Modular design provides ease of installation and matching configurations
- Low profile recessed housing is suitable for old or new work installations and is Type IC Rated
- Recessed ceiling back box features universal adjustable mounting brackets with quick-fit retaining clips to suit most ceiling types
- Slimline low profile surface mount housing eliminates need for recessing box in wall mount applications

Recessed Ceiling Mount

Electrical

- Diagnostic Battery Monitoring on all "EM" models
- Available with Master/Remote combinations
- Battery Diagnostic Circuit monitors battery status, detects cell failure and issues alert of reduced capacity and the need to replace battery
- Unique electronic driver circuit provides current control and protection ensuring optimum LED efficiency and life
- Universal 120/277 VAC field selectable input. All versions feature fully integral electronic components
- Premium long life high temperature rated, fused Nickel Cadmium battery
- Recessed AC Indicator and Test Switch
- Brownout sensing assures emergency illumination during periods of low line voltage
- Self-compensating solid state Constant Current Charger provides extended float life and rapid recharge
- Zero current LVCO ensures positive charge acceptance following extended discharge

Illumination

- Maintenance free LED Light source with 25+ years life expectancy
- Refractive light guide engineered to optimize LED utilization and illumination uniformity

Certification

- Approved for use in New York City calendar #48851
- UL Listed 3 hour emergency duration standard
- UL 924 Listed by Underwriters Laboratories and meets or exceeds all performance standards as required by NFPA 101, NFPA 70-NEC and OSHA
- California Energy Commission (CEC) Title 20 Compliant

UL LISTED

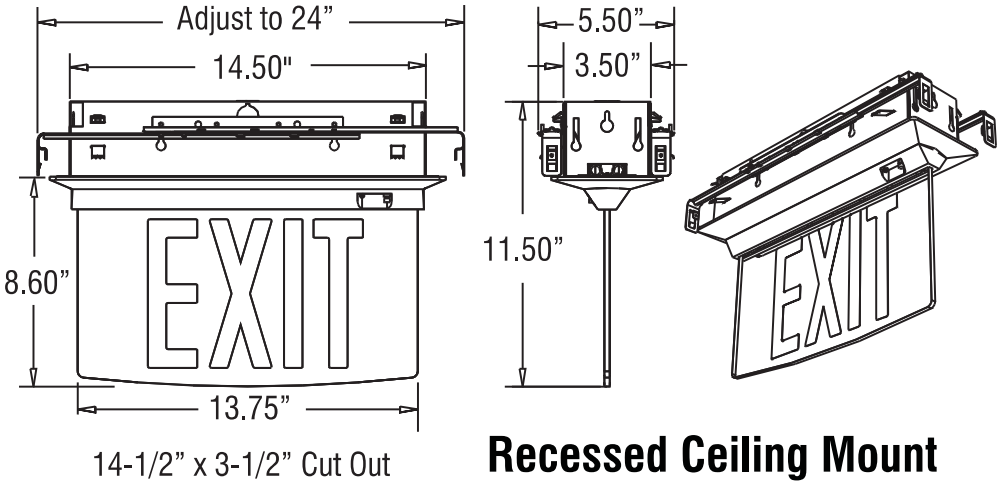
CEC Title 20 E Compliant

Warranty

- 5 year limited warranty

2575 Metropolitan Drive | Trevose, PA 19053 | T: 1.800.872.0879 | F: 215.244.4208 | mail@evenlite.com | www.evenlite.com

Sovereign LED Exit Signs



14-1/2” x 3-1/2” Cut Out

Recessed Ceiling Mount

Power Consumption				
Type		Volts	Max Watts	Power Factor
RED	AC Only	120 / 277	1.5	.70
RED	Battery Backup	120 / 277	2.5	.70
RED	Battery Backup with Remote	120 / 277	3.0	.73
GREEN	AC Only	120 / 277	2.3	.70
GREEN	Battery Backup	120 / 277	3.0	.76
GREEN	Battery Backup with Remote	120 / 277	4.0	.81

ORDERING GUIDE – SOV

Example: SOV-EM-R-1W-BA-RC-UC-SD-FT-FP

Model	Operation	Legend Size/ Letter Color	Faces/ Background	Trim/ Housing Color	Mounting	Chevron Direction	Options
SOV	**AC** AC Only 120/277 VAC **EM** Battery Backup Emergency	**R** RED Standard 6” EXIT **G** GREEN Standard 6” EXIT **NR** RED 8” EXIT **NG** GREEN 8” EXIT	**1C** Single Face, Clear Background (standard) **1M** Single Face, Mirror Background **2M** Double Face, Mirror Background (Mirror simulates clear background for double face exits) **1W** Single Face, White Background **2W** Double Face, White Background	**BA** Brushed Aluminum (standard) **WH** White Finish **BK** Black Finish **BR** Brushed Brass Painted Finish **CC** Custom Color (specify)	**Standard Mounting** **RC** Recessed Ceiling **Optional Mounting** **UP** Back Box Pre Shipped	**UC** Field Installed Adhesive Chevron Indicators **AR** Arrow Right EXIT> **AL** Arrow Left <EXIT **AA** Double Arrow <EXIT> **LR** Arrow Left/Arrow Right <EXIT/EXIT> (Double Face units only) *Factory installation of Chevrons is recommended for Double Face Signs*	**DK** Two Circuit Input –Specify Input Voltage (AC Models only) **DL** Damp location listed **EU** Euro Legends (Consult factory for full range) **F** Flash in Emergency Mode (EM Models) or continuous Flash in AC models **FA** Flash in AC and Emergency mode on 12-24V (AC or DC) normally-off fire alarm signal (Available for AC and EM models) **FB** FA Option including Buzzer **FZ** F Option including Buzzer **FP** Flat Panel (no curve on panel bottom) **IN** Inverted Legend – Use with Mullion Mount **IR** Self-Diagnostics with Infrared remote Testing (EM models only) **TLRT** Infrared hand held Transmitter (order separately) **LL** High/Low Level Master and Remote (available for AC and EM Models-Remote is Die Cast Exit Razor to match master) **SD** Self-Test / Self-Diagnostic(EM models Only) **VA** Other Input Supply Voltage (Consult Factory)
SOV							

Fill in fields from categories above and complete type and part number.

Type Number:	*Full Part Number:*

EVENLITE

LIFE SAFETY LIGHTING SOLUTIONS

www.evenlite.com

isolite

Exit Sign **EX**
Option 1 - Solid

TL2

Aluminum Thinline Die-Cast LED Exit Sign

CEC Title 20 Compliant

c UL us

FEATURES

- Thin architectural profile
- Illumination 7 times brighter than UL 924 requirement with super-bright, long-life LEDs
- Battery Back-up models without remote heads have a standard 4 hour runtime.
- UL Listed for Damp Location
- Up to 2 watts of remote capacity (3.6v)
- Compatible with our MVH and MVI remote heads
- Polycarbonate security cover available
- Available with low profile universal canopy, wall mount, or pendant mount
- All mounting options use standard 4S Junction Box (not included)
- All electronic components, including flexible circuit board, contained within the frame assembly
- High Temperature, Maintenance free, eco-friendly Nickel Metal Hydride battery with fuse protection
- Battery diagnostic system standard – battery status: detects cell failure and issues alert of reduced capacity and the need to replace battery
- Self-Test / Self-Diagnostic monitoring available
- Line-latch prevents unnecessary discharge of battery during installation. Loads will not illuminate until after application of utility power
- Brownout detection ensures emergency operation during periods of low line voltage
- Pendant available that hangs straight for ease of installation on sloped ceilings
- Sealed external momentary test switch and dual diagnostic LED indicator displays AC presence and Hi-Charge status
- Zero current low-voltage disconnect
- Unique electronic driver circuit provides current control and protection, ensuring optimum LED efficiency and life
- Specialty finishes available
- Master/Remote signs available. See TLMR2 and TLREM2
- Custom Wording signs available. See TLCG2
- 120/277 VAC field-selectable inputs

ORDERING INFORMATION *TL2-AC-G-1-BA-MB*

1. SERIES	2. OPERATION	3. ILLUMINATION	4. FACE COUNT	5. FRAME COLOR	4. MOUNTING
TL2 -	-	-	-	-	-
	AC AC Only **EM** Battery Backup	**G** Green **R** Red	**1** Single **2** Double **U** Universal	**BA** Brushed Aluminum **BK** Black **CC** Custom Color **WH** White	**MB** Back Mount **MPA** 12" Pendant Mount **MPB** 24" Pendant Mount **MPC** 36" Pendant Mount **MPD** 48" Pendant Mount **MPE** 60" Pendant Mount **MPF** 72" Pendant Mount **MTEB** Top/End/Back Mount

5. OPTIONS

BLANK = NO OPTION
CX Dual Circuit - 120/277 VAC (AC Only)
SD Self-Diagnostics (EM Only)
SR Self-Diagnostics + IR Remote Testing Receiver (EM Only)
EB Remote Capacity (EM Only)
FL Flasher
FA Fire Alarm Interface
VR Vandal Resistant Lens (Includes Tamper-Proof Screws)

ORDERING NOTES

1. Compatible with MVI and MVH remote heads
Accessories on the back of this document

TL2

Aluminum Thinline Die-Cast LED Exit Sign

ACCESSORIES; ORDER SEPARATELY

- TLRT = Infrared Remote Control
- WG 2 = Wireguard 14" X 10" X 4.5"
- WG 3 = Wireguard 14.5" X 6" X 10.5"
- WG 10 = Wireguard 13.5" X 12" X 16.5"

CONSTRUCTION

- Injection molded internal cavity reflector provides ease of installation and maintenance together with perfectly even legend illumination
- Two piece, heavy-duty walls constructed from die cast aluminum alloy
- Removable front stencil face with overlapping light seal

INPUT POWER

- AC models: 2 watts
- EM models: 2.4 watts

LETTERS

- 6.0" high; 0.75" stroke

ARROWS

- NFPA type, universal field-selectable chevrons

WEIGHT

- AC: 8 lbs
- EM: 8 lbs

TEMPERATURE RATING

- From 50°F to 104°F

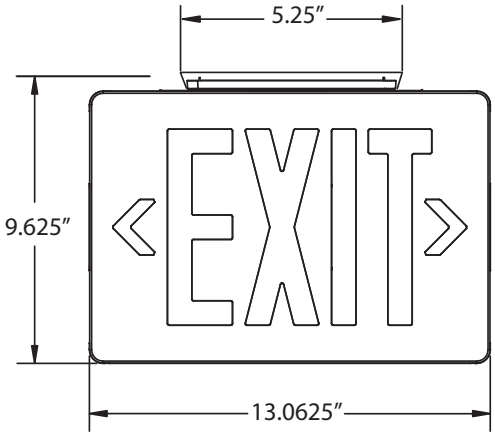
APPROVALS

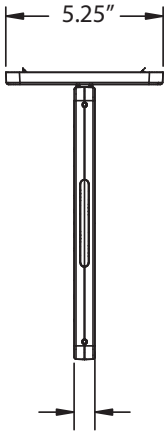
- UL 924
- CEC Title 20 Compliant
- UL 924 Damp Location
- NFPA 101 Life Safety Code
- NFPA 70- NEC
- OSHA

WARRANTY

- Isolite offers a 5-year limited warranty. For further details, refer to General Warranty and Obligations in the Isolite manual or on our website

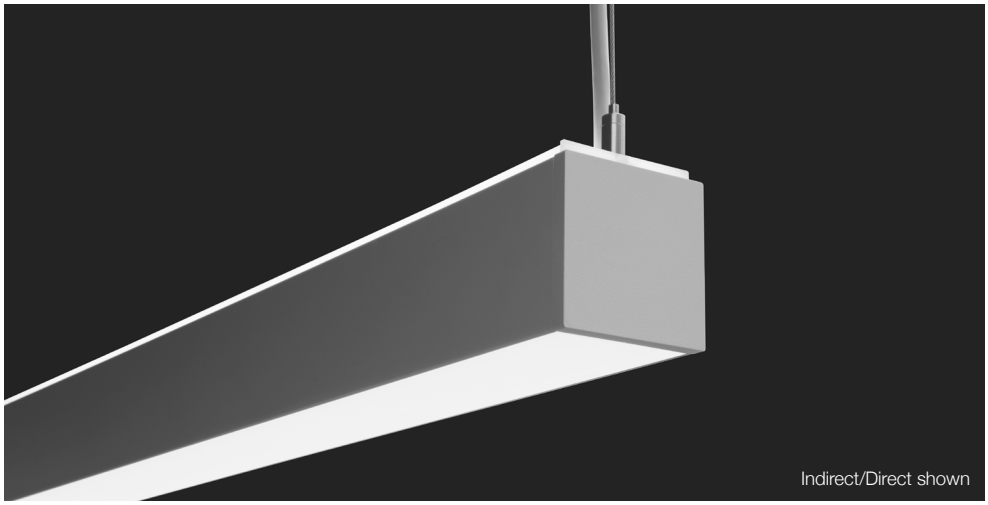
DIMENSIONS





0.625" Single or Double face

HPX Product Family

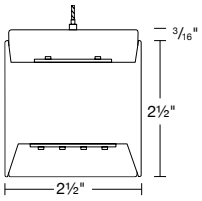


The High Performance 2.5" Aperture (HPX) is a patented LED linear luminaire with a square micro profile and internal driver design. This line of light luminaire delivers excellent performance, and is equipped with a unique LED configuration for superior illumination. Output can be enhanced with advanced optical options. Available in Pendant and Surface Mount, HPX can be tailored from 2' to 12' sections in 1' increments.

Signal White is standard finish

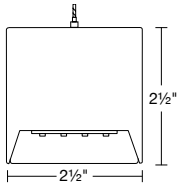
CROSS SECTIONS

Indirect/Direct
Top Glow Diffuser
(standard)



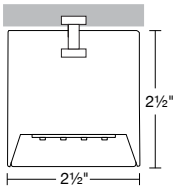
Flush Downlight Diffuser
(standard)

Direct



Flush Downlight Diffuser
(standard)

Surface Mount



Flush Downlight Diffuser
(standard)

LUMEN OUTPUT PACKAGES

S	B	H	V
Standard	Boosted Standard	High	Very High

PERFORMANCE

Up to
2057
Lumens per **Foot**

Up to
125
Lumens per **Watt**

Fine TUNE GENERATION 1 Option Available

Protected by one or more US Patents: 8915613; 9681516,B2; D702,390

Finelite, Inc. • 30500 Whipple Road • Union City • CA 94587-1530 • P: 510-441-1100 • F: 510-441-1510 • www.finelite.com

HPX Product Family

BODY TYPE

Platform	Series Name	Luminaire Type	Luminaire Distribution	Total Run Length of Configuration
HP - High Performance	**X** - 2.5" Square	**P** - Pendant **SM** - Surface Mount	**D** - Direct **ID** - Indirect/Direct	_____ Minimum 2' section length. Increments of 1'; 12' maximum section length

OUTPUT and LED TYPE

Uplight Output ID Only	Downlight Output	LED CRI/CCT
S - Standard **B** - Boosted Standard **H** - High **V** - Very High **TL** - Tailored: _____ lm/ft *	**S** - Standard **B** - Boosted Standard **H** - High **V** - Very High **TL** - Tailored: _____ lm/ft *	**830** - 80 CRI min, 3000K **835** - 80 CRI min, 3500K **840** - 80 CRI min, 4000K **930** - 90 CRI min, 3000K **935** - 90 CRI min, 3500K **940** - 90 CRI min, 4000K **8TW** - 80 CRI min, Tunable White **9TW** - 90 CRI min, Tunable White

* Specify lm/ft of outputs between Standard (S) and Very High (V). Consult factory for tailored lumen output outside of this range.

MECHANICAL/OPTICAL OPTIONS

Uplight Option ID Only	Downlight Option
TG - Top Glow (Standard) **F** - Flush Diffuser **WSO** - Widespread Optic **WSOTG** - Widespread Optic with Top Glow **ASYTG-L** - Asymmetric Left Optic with Top Glow **ASYTG-R** - Asymmetric Right Optic with Top Glow	**F** - Flush

ELECTRICAL OPTIONS

Voltage	Circuiting [1]	Driver Selection [2]	
120 - 120 Voltage **277** - 277 Voltage **347** - 347 Voltage	**SC** - Single Circuit* One single circuit in a run **DC** - Dual Circuit* Independent control of up and down separately in an I/D style fixture **MC** - Multi Circuit* More than one switch leg or zone (not 'DC' indepedent control of up and down separately for an I/D style fixture). Factory shop drawings required *Battery, Night Light, and Emergency to Generator circuits are in addition to the normal luminaire circuit(s)	**0-10V Driver Options** **FC-10%** - 0-10V 10% (standard) [3] **FC-1%** - 0-10V 1% [3] **OSR-10%** - Osram OTi, 0-10V 10% [3] **OSR-1%** - Osram OTi, 0-10V 1% [3] **ELD-10V** - EldoLED SOLOdrive, 0-10V 0.1% **10V-TW** - Osram OTi, 0-10V 10% *(Tunable White)* [3] **DALI Driver Options** **FC-DALI** - DALI 1% **OSR-DALI** - Osram Dexal, 1% **ELD-DALI** - EldoLED SOLOdrive, DALI 0.1% **DALI-TW** - EldoLED Dual Drive Light Shape, 1% *(Tunable White)*	**DMX Driver Options** **FIN-DMX** - Finelite DMX 1% *(Tunable White - FineTUNE Controls Only)* [4] **DMX** - EldoLED POWERdrive, 0.1% **DMX-TW** - EldoLED POWERdrive, 0.1% *(Tunable White)* **Lutron Driver Options** **LUT-ES1** - Lutron, Ecosystem 1% **LUT-ES5** - Lutron, Ecosystem 5% **LUT-2W** - Lutron, 2-wire (120v only) 1% **LUT-TW** - Lutron T-Series, EcoSystem 1% *(Tunable White)* See Page 3 for additional driver options and details

MOUNTING OPTIONS

Mounting Method	Hardware	Endcap Style	Finish
FA50 - Fully Adjustable 50" **FA100** - Fully Adjustable 100" **FA150** - Fully Adjustable 150" **FA200** - Fully Adjustable 200" **FA250** - Fully Adjustable 250" **FA300** - Fully Adjustable 300" **FM** - Flexible Mounting [5]	**C1** - 1" T-Bar **C2** - 9/16" T-Bar **C3** - Screw Slot **C4** - Hard Ceiling	**FE** - Flat Endcap	**SW** - Signal White **FB** - Finelite Black [6] **SA** - Satin Aluminum [6] **####** - RAL Color Code [6] _____

OTHER OPTIONS

Emergency Style (Optional)	Integrated Sensor (Optional)
FAC CHO - Factory Choice Battery Back-up **EM/GEN** - Emergency to Generator **NL** - Night Light **BSL310LP** - Bodine Battery Back up Low Profile **GTD** - Generator Transfer Device	**OBO** - Occupancy **OBD** - Daylight **OBE** - Enlighted [7]

[1] Contact factory for switching options
[2] For Indirect/Direct lengths 3' and greater, separate dimming for uplight and downlight available
[3] Add DTO to gain "Dim to Off" functionality (FC-10% - DTO)
[4] B & V outputs only
[5] Direct only
[6] 20 Business day lead time for color
[7] Enlightened components installed by Finelite; Provided by OTHER

Finelite, Inc. • 30500 Whipple Road • Union City • CA 94587-1530 • P: 510-441-1100 • F: 510-441-1510 • www.finelite.com

HPX Product Family

SPECIFICATIONS

BODY TYPE

CONSTRUCTION: Precision-cut 6061-T6 extruded aluminum body. Internal joiner system, plug-together wiring, standard.

LENGTHS: Any length, 2' minimum section length. Increments of 1'. 12' maximum section length. For Indirect/Direct, select a minimum body length of 3' or greater when requiring dual circuiting or when uplight and downlight outputs differ.

ARRAY TYPE

LIGHT OUTPUT: Four lumen packages available, Standard (**S**), Boosted Standard (**B**), High (**H**), and Very High (**V**). A separate chart summarizes lumen distribution and wattage. For Tailored Outputs outside of range from Standard (**S**) to Very High (**V**), consult factory. Light engines are replaceable.

MECHANICAL FEATURES

UPLIGHT OPTION [1]: Patented Top Glow Frost White Diffuser, standard. 12' maximum diffuser length. Optical distribution pattern options include Widespread Optic (**WSO**); WSO enables increased luminaire spacing with improved ceiling uniformity, and Asymmetric (**ASYTG-L** / **ASYTG-R**). Asymmetric optic directs light in a specific direction. ASYTG-L distributes light to the left, ASYTG-R distributes light to the right of the luminaire. Consult factory for more tailored lumen outputs.

DOWNLIGHT OPTION: 12' maximum diffuser length. Flush (**F**) frost white snap-in diffuser, standard; 73% transmissive, 99% diffusion. Internal secondary diffusers at corners ensure visually seamless, uniform, continuous illumination. Consult factory for more tailored lumen outputs.

ELECTRICAL FEATURES

STATIC WHITE FEED: 18-gauge/5-conductor single-circuit feed, standard. 14-gauge feed used when luminaire current exceeds 5 amps.

TUNABLE WHITE FEED: Standard with one 18-gauge/5-conductor single-circuit feed. 14-gauge feed used when fixture current exceeds 5 amps. DMX and power feed at same location (standard). DMX feeds cannot be cut or spliced. DMX feeds should be ordered based on fixed lengths.

STATIC WHITE DRIVER: Replaceable 120V, 277V, and 347V Constant Current Reduction dimming driver standard. Can be wired dimming or non-dimming. 0-10V dimming controls with a range of 10% - 100%. Dimming to 1% available; Consult factory. Separate dimming for uplight and downlight available. Driver is fully accessible from below the ceiling.

– **Power Factor:** ≥ 0.9
– **Total Harmonic Distortion (THD):** <20%
– **Expected driver lifetime:** 100,000 hours

LUTRON STATIC DRIVER OPTIONS:

– **LUTES1** Hi-lume 1% EcoSystem with Soft-On, Fade-to-Black dimming (LDE1 series)
– **LUTES5** 5-Series 5% EcoSystem (LDE5 Series)
– **LUT2W** Hi-lume 1% 2-wire, 120V forward phase dimming (LTEA series);

TUNABLE WHITE DRIVER: Replaceable LED driver. Driver is accessible from below the ceiling. 120V/277V.

– **Power factor** ≥0.9
– **Total Harmonic Distortion (THD):** <20%
– **Dimming Range:** 100 - 1%
– **Expected driver lifetime:** 100,000 hours

LUTRON TUNABLE WHITE DRIVER OPTION: LUTDTW 1% T-Series 2-Channel Digital Tunable White (PSQ Series).

MOUNTING TYPE

HANGING HARDWARE:

– **Pendant:** 50" Fully Adjustable (**FA**) plated steel aircraft cable with safety stop hardware standard. Contact factory for additional lengths up to 150". The Flexible Mounting Bracket (**FM**) [2] adjusts the suspension points to accomodate existing architecture. Suspension points adjust up to 2' in from the end of 8' to 12' fixture lengths and up to 1' in on shorter lengths.
– **Surface Mount:** Lay-in ceiling types: caddy clip with 1/4"-20 stud and nut. Drywall or concrete surfaces (walls or ceilings): 1/4"-20 stud and nut (provided by others).

OTHER FEATURES

ENDCAPS: Flat diecast aluminum endcaps add 1/4" to each end of luminaire.

EMERGENCY STYLE: Optional emergency to generator/inverter wiring, internal generator transfer switch, nightlight wiring, step-dimming driver, backup battery. Factory choice low-profile backup battery available. 8' minimum luminaire length for low profile battery pack. Backup batteries deliver 1608 lumens. Half of a 4' (one side) section will be illuminated in EM mode. Solid Endcap (**SE**) required at end with a battery pack.

TUNABLE WHITE ELECTRICAL OPTIONS:

– **TW Driver Options 0-10V:** EM/GEN, GTD, or Battery Back-up
– **FineTune DMX:** EM/GEN or Battery Back-up
– **DMX:** Battery Back-up
– **DALI:** EM/GEN, GTD, or Battery Back-up
– **LUTRON:** EM/GEN, GTD, or Battery Back-up

[1] Indirect/Direct (ID) only
[2] Direct only

Continued

Finelite, Inc. • 30500 Whipple Road • Union City • CA 94587-1530 • P: 510-441-1100 • F: 510-441-1510 • www.finelite.com

HPX Product Family

SPECIFICATIONS

INTEGRATED SENSORS: Integrated PIR Occupancy, Daylight, and Onboard Enlighted sensors available. For Indirect/Direct, select a minimum body length of 4' or greater when requiring dual circuiting.

FINISHES: Finelite Signal White (**SW**) powder coat standard. Finelite Black (RAL 9005) with semi gloss fine texture (**FB**) [3] and satin Aluminum (**SA**) [3] are available. Optional Adders: 185 RAL colors. [3]

LABELS: Luminaire and electrical components are ETL-listed conforming to UL 1598 in the U.S.A. and CAN/CSA C22.2 No. 250.0 in Canada. In accordance with NEC Code 410.130 (G), this luminaire contains an internal driver disconnect. UL 924 and UL 2108 - PoE options available on request, contact factory for more details. These fixtures are rated for Damp Location. Finelite products use electronic components that are RoHS compliant, and the mechanical components of the luminaire have been verified to not knowingly contain any restricted substances listed per RoHS Directive 2015/863. HPX can be used to comply with 2016 Title 24, Part 6 (JA8); high efficacy LED light source requirements.

WEIGHT: 2.3 lb/ft.

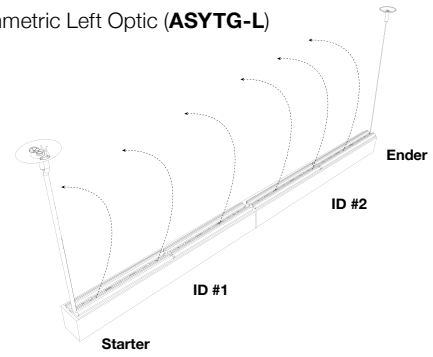
WARRANTY: 10-year performance-based warranty on all standard components. Optional accessories such as emergency battery packs are covered by their individual manufacturer warranties.

[3] 20 Business day lead time for color

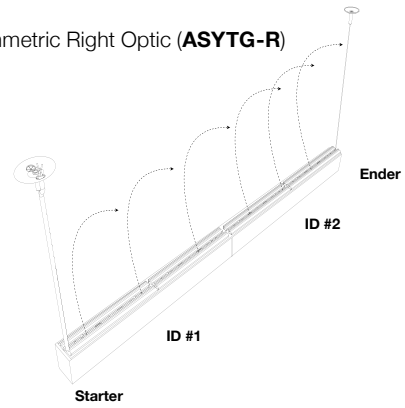
ASYMMETRIC OPTIC OPTIONS

Use this tool to understand how to specify Asymmetric for your project. The diagrams below show a linear run from power feed to ender. Specify, ASYTG-L distributes light to the left or ASYTG-R distributes light to the right.

Asymmetric Left Optic (**ASYTG-L**)



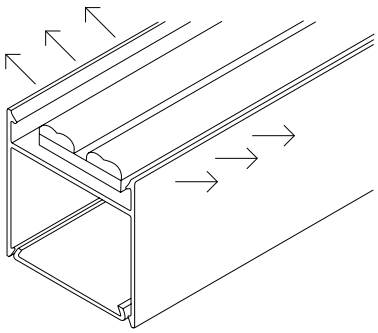
Asymmetric Right Optic (**ASYTG-R**)



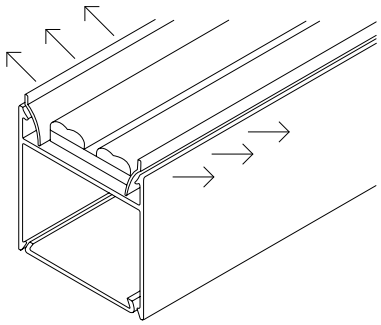
WIDESPREAD OPTIC OPTIONS

Wide Spread Optic (**WSO**) delivers a batwing distribution for improved performance.

Widespread Optic (**WSO**)



Widespread Optic Top Glow (**WSOTG**)



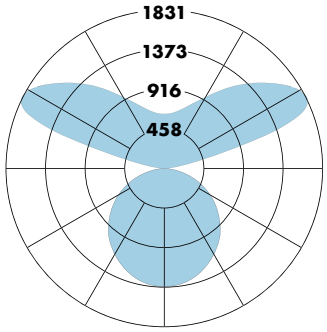
HPX Product Family

Indirect/Direct with Widespread Optic Photometry

4' Luminaire 3500K

HPX-P-ID-V-V-835-WSO-F
Uplight: Widespread Optic / **Downlight:** Flush

Distribution: 51% Up (**V**) / 49% Down (**V**)
Efficacy: 119 lm/W
Uplight: 4223 lumens (1056 lumens/ft)
Downlight: 4005 lumens (1001 lumens/ft)
Total luminaire output: 8228 lumens
69.0 watts
Peak Candela Value: 1375 @ 0°
CRI: 80 / CCT: 3500K
ITL LM79 Report 92549



CANDLEPOWER SUMMARY

	0.0	22.5	45.0	67.5	90.0	Flux
0	1375	1375	1375	1375	1375	
5	1367	1368	1368	1368	1369	130
15	1322	1316	1322	1323	1320	373
25	1230	1218	1227	1228	1225	565
35	1094	1084	1092	1091	1087	681
45	922	915	922	918	915	708
55	723	718	723	719	716	643
65	507	504	507	505	505	500
75	286	286	290	291	291	306
85	85	86	90	92	91	99
90	0	0	0	0	0	
95	37	83	214	99	78	141
105	145	218	811	923	651	625
115	259	334	763	1652	1820	926
125	364	438	777	1423	1681	820
135	436	502	775	1197	1390	656
145	503	552	735	981	1097	483
155	561	589	689	801	851	324
165	605	616	653	690	703	186
175	627	629	633	636	638	61
180	630	630	630	630	630	x

Total Light Output, 3500K, 80 CRI (Lumens)- 4' Luminaure				
	↑S[1]	↑B[1]	↑H[1]	↑V[2]
↓S[1]	3368 [↑51% | 49%↓]	3813 [↑57% | 43%↓]	4924 [↑67% | 33%↓]	5862 [↑72% | 28%↓]
↓B[1]	3790 [↑46% | 54%↓]	4234 [↑51% | 49%↓]	5346 [↑61% | 39%↓]	6284 [↑67% | 33%↓]
↓H[1]	4844 [↑36% | 64%↓]	5288 [↑41% | 59%↓]	6400 [↑51% | 49%↓]	7338 [↑58% | 42%↓]
↓V[1]	5734 [↑30% | 70%↓]	6179 [↑35% | 65%↓]	7290 [↑45% | 55%↓]	8228 [↑51% | 49%↓]

Light Output, 3500K, 80 CRI (Lumens Per Foot)				
	↑S[1]	↑B[1]	↑H[1]	↑V[2]
↓S[1]	842	953	1231	1466
↓B[1]	947	1059	1336	1571
↓H[1]	1211	1322	1600	1835
↓V[1]	1433	1545	1822	2057

Power, 3500K, 80 CRI (Watts Per Foot)				
	↑S[1]	↑B[1]	↑H[1]	↑V[2]
↓S[1]	6.8	7.7	10.0	12.0
↓B[1]	7.7	8.6	10.9	12.9
↓H[1]	10.0	10.9	13.2	15.2
↓V[1]	12.0	12.9	15.2	17.3

Efficacy, 3500K, 80 CRI (Lumens Per Watt)				
	↑S[1]	↑B[1]	↑H[1]	↑V[2]
↓S[1]	125	124	123	122
↓B[1]	124	123	123	122
↓H[1]	121	121	121	120
↓V[1]	119	120	120	119

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**) / Standard Output (**S**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 4924 lm x 0.789 = 3885 lm

Total Light Output per Foot: 1231 lm x 0.789 = 971 lm

watts/foot: 10.0 W/ft.

$$\textbf{Efficacy} = \frac{971\ \frac{\text{lm}}{\text{ft.}}}{10.0\ \frac{\text{W}}{\text{ft.}}} = 97\ \text{lm/W}$$

S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output
[1] Based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 92549

Luminaire **PB**
Option 1
Circular pendant

RIM ROUND PENDANT

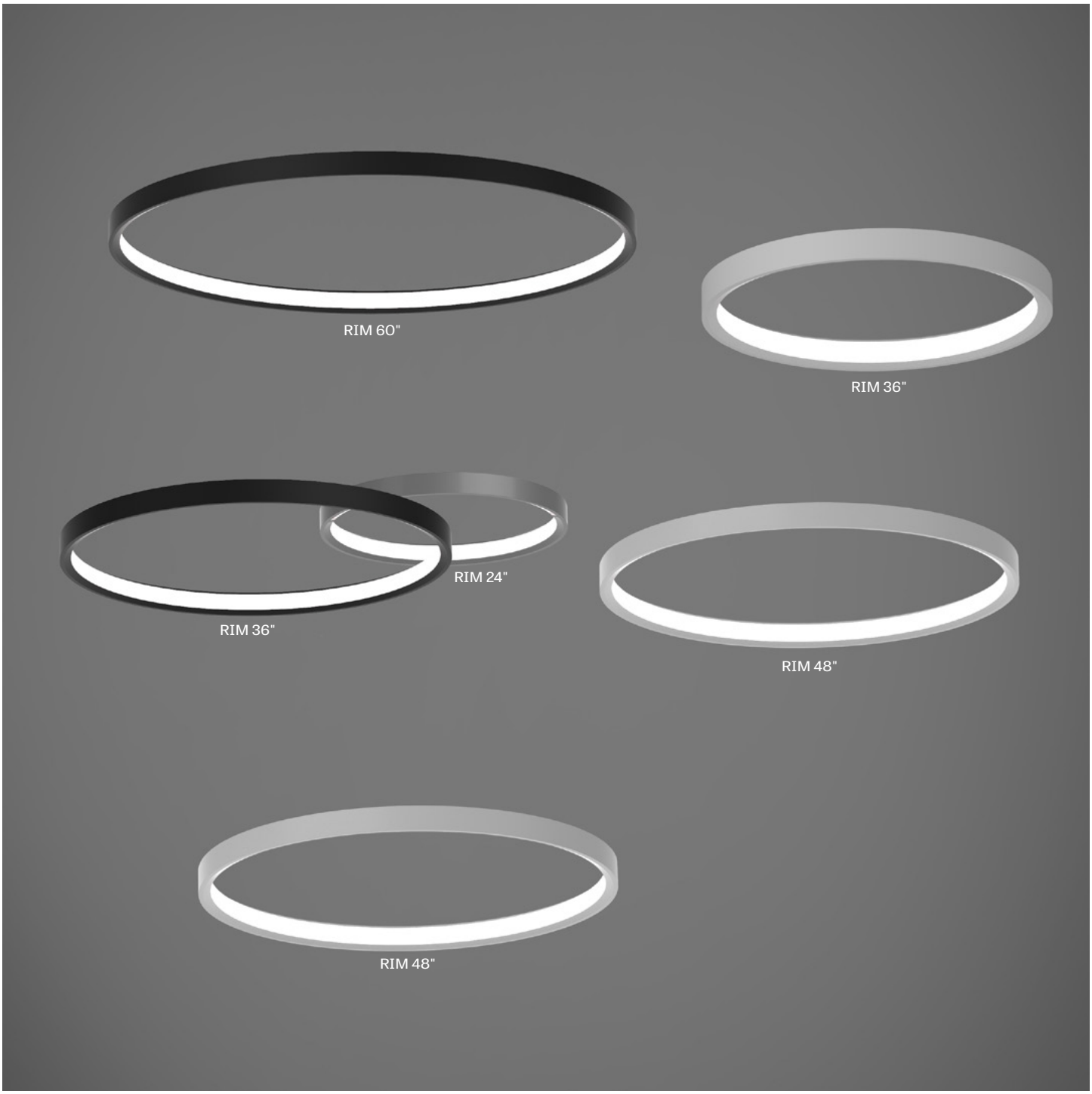
LUMENWERX
WWW.LUMENWERX.COM

DESCRIPTION

Rim Round combines generous ambient illumination with elegant geometry. The 2" high extruded aluminum frame is formed and finished into a seamless ring that can be painted in a wide range of standard and custom colors. The driver installs remotely, either above or below the ceiling. The three-to-four point suspension is available in an ultra-clean integrated power-over-cable option.

Rim Round is available in four diameters: 24", 36" 48" and 60". Nominal light output ranges from 2000 to 10000 lumens, with efficacy up to 86 lumens per watt.

Rim is also available in Square and Linear forms and with ChromaWerx Sola, Duo, and Quadro (see separate specification sheets)



Intertek

RIM ROUND PENDANT

LUMENWERX
WWW.LUMENWERX.COM

5 YEARS WARRANTY

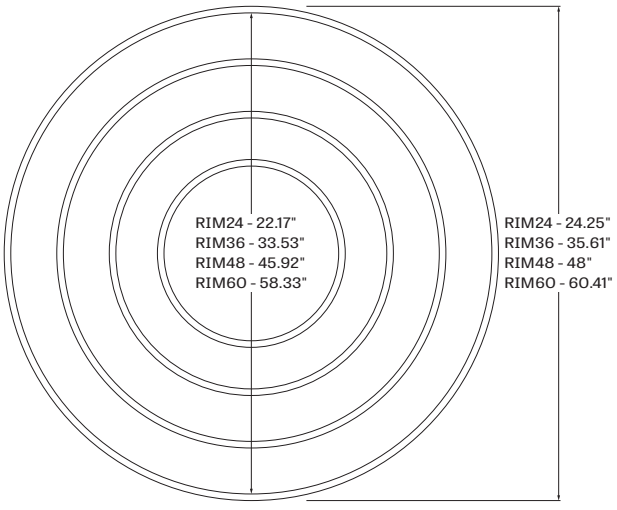
ORDER GUIDE

RIMRP		ULO	LED	90
LUMINAIRE ID	**SIZE**	**OPTICS**	**LIGHT SOURCE**	**CRI**
RIMRP - Rim round pendant	**24** - 24" diameter **36** - 36" diameter **48** - 48" diameter **60** - 60" diameter	**ULO** - Uniform Lambertian Optic	**LED** - High performance LED	**90** - 90CRI

				1
LUMEN PACKAGES	**COLOR TEMP.**	**VOLTAGE**	**REMOTE DRIVER**	**ELECTRICAL**
####lm - L2000lm - M3000lm - H4000lm (RIM24) **####lm** - L3000lm - M4500lm - H6000lm (RIM36) **####lm** - L4000lm - M6000lm - H8000lm (RIM48) **####lm** - L5000lm - M7500lm - H10000lm (RIM60) **L**-Low, **M**-Medium **H**-High, consult factory for other	**27** - 2700K **30** - 3000K **35** - 3500K **40** - 4000K	**120** - 120V **277** - 277V **UNV** - 120V-277V	**D1** - 1% 0-10V **DA** - DALI **LTEA2W** - Lutron 1% - 2 wire FP 120V **LDE1** - Lutron Hi-lume 1% Eco **LDE5** - Lutron 5% EcoSystem	**1** - 1 circuit

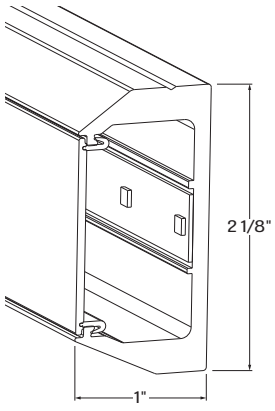
MOUNTING					FINISH
DRIVER BOX	**CANOPY FINISH**	**POWER**	**MOUNTING POINTS**	**HEIGHT**	
RCD - Round Canopy Driver box* **RDB** - Remote Driver Box See page 3 * RCD is NOT available: For over 6000lm. Lutron drivers - over 3500lm	**W** - Matte white **A** - Aluminum **B** - Black **CF#** - Custom finish specify RAL#	**POC##** - Integrated Suspention Power Over Cable* **BAC##** - Black power cord + Aircraft Cable **WAC##** - White power cord + Aircraft Cable Cables length in inches (Min. 48") * For more information see page 3	**1C** - 1 canopy **3C** - 3 canopies **4C** - 4 canopies	**##IN** - Distance from the canopy to the fixture in inches* * For **1 canopy** option, the minimum mounting heights are: Ø 24" fixture: min height 20" Ø 36" fixture: min height 23" Ø 48" fixture: min height 31" Ø 60" fixture: min height 40"	**W** - Matte white **AL** - Aluminum **BK** - Black **CF#** - Custom finish specify RAL#
See website for the Pendant Mounting Guide					

TOP VIEW



RIMRP - RIM Pendant

3D CROSS SECTION

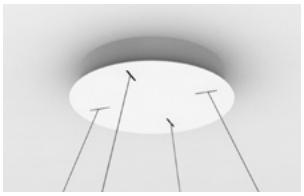


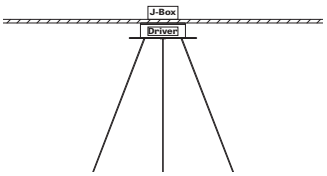
RIMRP - Rim round

MOUNTING OPTIONS

All examples below are also available with air craft cable.

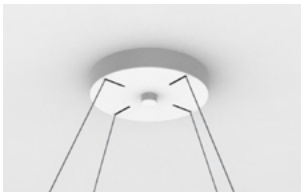
ROUND CANOPY DRIVER BOX

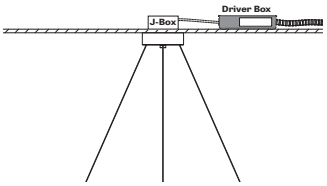




RCD - Round Canopy Driver box - driver is furnished in a 6" or 9" diameter, 2" deep enclosure that also supports suspension and power cables. Enclosure is available in standard finishes (see ordering code).

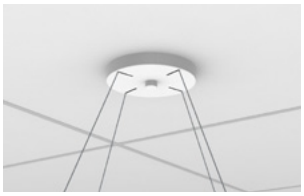
REMOTE DRIVER BOX IN DRYWALL

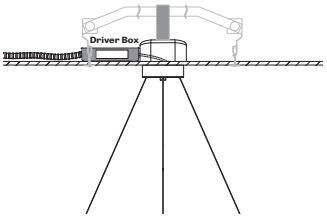




RDB - Drywall remote driver - driver is in a 20"x4"x2" enclosure with brackets for mounting to ceiling joists or other supporting members. The 5 1/2" diameter x 1 5/8" deep wiring compartment canopy conceals and supports suspension and power cables. It is available in standard finishes (see ordering code).

REMOTE DRIVER BOX IN GRID





RDB - Ceiling remote driver for grid ceiling - driver is in a 20"x4"x2" enclosure with brackets for mounting to ceiling runners. The 5 1/2" diameter x 1 5/8" deep wiring compartment conceals and supports for suspension and power cables.

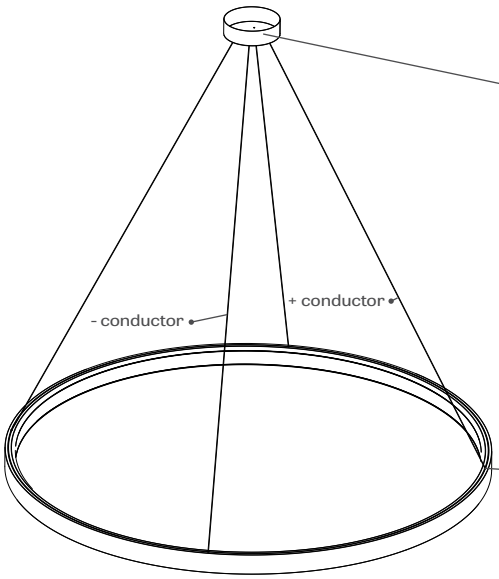
Note : Support hardware is not supplied.

INTEGRATED SUSPENSION AND POWER OVER CABLE (POC)

The integrated suspension and power-over-cable option provides an elegant mounting option without the familiar jacketed power cord. Current from the driver to the LED arrays flows through seven-strand galvanized copper conductors. A dielectric polymer coating insulates the cable, which is supported by insulated holders at the ceiling and luminaire mounting plate.

Our standard integrated power-over-cable supports all dimming and control protocols available through the driver options without additional conductors.

Seven-strand galvanized copper conductors.
Cable diameter - 0.06" (1.55mm)



Hinged cable holder with concealed feed

Color coded terminal block for ease of connection

RIM ROUND PENDANT

LUMENWERX
WWW.LUMENWERX.COM

OPTICS

UNIFORM EFFICIENCY LAMBERTIAN OPTIC (ULO) - thermoformed from impact-modified white PMMA, the ULO optic provides even luminosity, with up to 88% transmission.
Combined with the LED array running around the inside of the housing, the open form and ULO optic create a widespread 50% direct and 50% direct light distribution with spacing criteria of 1.6.

LIGHT SOURCE - LED

Custom array of mid-flux LED's are mounted directly to the housing for optimal thermal performance. Available in 3000K, 3500K and 4000K with 90 CRI and elevated R9 value. Color consistency is maintained to 3 SDCM. LEDs are operated at a reduced drive current to optimize efficacy and lumen maintenance.
All LEDs have been tested in accordance with IESNA LM-80-08 and results have shown L80 lumen maintenance are greater than 60,000 hours. Absolute product photometry is measured and presented in accordance with IESNA LM-79, unless otherwise indicated.

PERFORMANCE FOR 24" DIAMETER

LED output	Color Temp	Watts	Nominal Delivered Lumens	Efficacy LPW
low output	4000K	23.5	2000	86
medium output	4000K	36	3000	83
high output	4000K	49.5	4000	81

PERFORMANCE FOR 36" DIAMETER

LED output	Color Temp	Watts	Nominal Delivered Lumens	Efficacy LPW
low output	4000K	35	3000	86
medium output	4000K	54	4500	83
high output	4000K	74	6000	81

PERFORMANCE FOR 48" DIAMETER

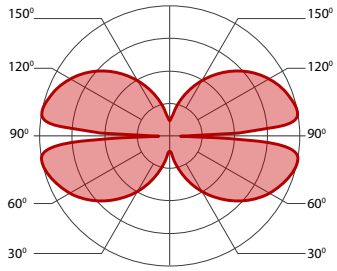
LED output	Color Temp	Watts	Nominal Delivered Lumens	Efficacy LPW
low output	4000K	46.5	4000	86
medium output	4000K	72.5	6000	83
high output	4000K	99	8000	81

PERFORMANCE FOR 60" DIAMETER

LED output	Color Temp	Watts	Nominal Delivered Lumens	Efficacy LPW
low output	4000K	58	5000	86
medium output	4000K	90.5	7500	83
high output	4000K	123.5	10000	81

Multiplier @ CRI90

CCT (K)	Watts	LPW
2700	1.09	0.92
3000	1.05	0.95
3500	1.02	0.98
4000	1.00	1.00
5000	0.94	1.07
6500	0.95	1.06



ELECTRICAL

Factory-set, adjustable output current LED driver with universal (120-277VAC) input. Dimmable from 100% to 1% with 0-10V dimming control. Rated life (90% survivorship) of 50,000 hours at 50°C max. ambient (and 70°C max. case) temperature. At maximum driver load: Efficiency>84%, PF>0.9, THD<20%. Other specifiable options include Lutron Hi-Lume 1% (specify 2-wire, or Ecosystem Dim-to-Off), Lutron 5-Series (5% Ecosystem), DMX (RDM compatible) and DALI protocol drivers. All of our standard 0-10V drivers are NEMA 410 compliant.

FINISH

Interior - 95% reflective, matte white powder coating
Exterior - matte white, matte black or aluminum powder coating.
Custom finishes are also available.

CONSTRUCTION

Housing - Rolled and seamlessly welded aluminum extrusion, wide variety of colored powder coating
Diffuser - Uniform lambertian optic, co-extruded flexible polycarbonate satine finished lens

WEIGHT

Rim round 24 - 5lbs - 2.3kg
Rim round 36 - 7.3lbs - 3.3kg
Rim round 48 - 10lbs - 4.6kg
Rim round 60 - 12lbs - 5.5kg

CERTIFICATIONS

ETL - Rated for Indoor Dry/Damp locations. Conforms to UL Standard 1598 and certified to CAN/CSA Standard C22.2 No. 250.0.

WARRANTY

LumenWerx provides a five-year limited warranty of electrical and mechanical performance of the luminaires, including the LED boards, drivers, and auxiliary electronics. LumenWerx will repair or replace defective luminaires or components at our discretion, provided they have been installed and operated in accordance with our specifications. Other limitations apply, please refer to the full warranty on our website.

WARP

WEB PIN 276

Luminaire **PB**
Option 2
Circular pendant

GENERAL SPECIFICATION

Product Overview:

Our revolutionary triple circuit luminaire delivers high efficiency diffused, spot and indirect light, allowing you to transition from general ambient to mood lighting. Available in two sizes 18" & 24", the Warp family offers two styles of pendant plus a ceiling mounted version. The color temperature of each light source can be individually selected to deliver an effect best suited to the application. New to the Warp are a wide array of contemporary decorative colors to accent your architectural scene.

Body: Aluminum and steel.

Canopy finish: Powder coated.

Suspension: Steel cables.

Power cable: Silver braided.

Diffuser: Acrylic.

Drivers: HPF electronic drivers for 120-277V (EU-240V)

Integral emergency system: Emergency option provides a 1.5 hour (3 hours for EU) emergency lighting facility. The self contained system includes the inverter module, NiCad batteries, LED charge indicator and test switch (NA only). Integral emergency EU luminaires have a 270mm/10.5" DIA x 48mm/2" height canopy with LED charge indicator. Not available with a 347V supply.

Remote emergency: Emergency option provides a 1.5 hour (3 hours for EU) emergency lighting facility. The remote system includes the inverter module, NiCad batteries and a remote wall/ceiling LED charge indicator and test switch (NA only) Maximum distance between wall/ceiling plate and luminaire is 4.5m/15'. Test switch fits a single gang box (not supplied).

Mechanical: Luminaires mount directly to a J box (by others - North America only).

L70 @25deg C: > 50,000 hrs.

Delivered lumens: Delivered lumens & LPW based on 4000K (min 80 CRI).

Approvals: Damp Location (Indoor use only).

Design: US Design Patent Pending.

WARP

Designed by: Serge Cornelissen.

MOUNTING & OPTICS


Suspended Direct


Suspended Direct/Indirect


Direct


Direct-indirect


Spot Only


Direct diffused and indirect light


SPOT OFF


SPOT ON

The shape of the diffuser is designed to create a hidden cavity for the central light source allowing for a clean, smooth contour.

WARP

HOW TO ORDER

A SPECIFY LUMINAIRE

Code	Diameter (A)	Light Direction	Wattage	Delivered lms	LPW	Height (B)
AN1	18"	Direct	22W	3262	146	6"
AN2	24"	Direct	34W	4873	145	6.5"
AN3	18"	Direct/Indirect	43W	5667	131	6"
AN4	24"	Direct/Indirect	54W	7174	132	6.5"

Additional Information

This fixture is wired for 3 circuits, in order to have each light source operate independently 2 power cables are supplied. For all other wiring options, consult factory.

B SPECIFY CCT (DIRECT)

J2	3000K (min 80 CRI)
J3	3500K (min 80 CRI)
J4	4000K (min 80 CRI)

C SPECIFY CCT (INDIRECT)

K0	Indirect CCT not required
K2	3000K (min 80 CRI)
K3	3500K (min 80 CRI)
K4	4000K (min 80 CRI)

D SPECIFY UPLIGHT DIFFUSER

U0	Uplight diffuser not required
U1	Clear diffuser
U2	Opal diffuser

E SPECIFY DIMMING

D1	0-10V Dimming (1.0%)
D2	0-10V Dimming (0.1%)
D3	347V, 0-10V Dimming (1.0%)
D4	DALI Dimming (0.1%)
D5	DALI Dimming (1.0%)
D6	DSI (EU only)
D7	switchDim (EU only)

Additional Information

D6 & D7 dimming not available in North America.

WARP

F SPECIFY FIXTURE FINISH

F1	White
F20	Silver Metallic
F25	Gold Metallic
F44	Midnight Blue Metallic - Textured
F45	Copper Metallic
F46	Charcoal Metallic - Textured
F47	Bronze Metallic - Textured
F50	Black Metallic - Textured
F52	Champagne Metallic
F53	Red Metallic - Textured

G SPECIFY CANOPY FINISH

BY1	White
BY20	Silver Metallic
BY25	Gold Metallic
BY44	Midnight Blue Metallic - Textured
BY45	Copper Metallic
BY46	Charcoal Metallic - Textured
BY47	Bronze Metallic - Textured
BY50	Black Metallic - Textured
BY52	Champagne Metallic
BY53	Red Metallic - Textured

H SPECIFY LUMEN OUTPUT

L0	100% of standard output
L1	Lumen & wattage reduction to approximately 75% of standard output
L2	Lumen & wattage reduction to approximately 50% of standard output
L3	Lumen & wattage reduction to approximately 25% of standard output

Additional Information

Custom reduction percentages available upon request.

I SPECIFY EMERGENCY

E0	Emergency system not required
E1	Integral emergency system (direct illumination only, not available with D3)
E2	Remote emergency

J SPECIFY DOWNLIGHT

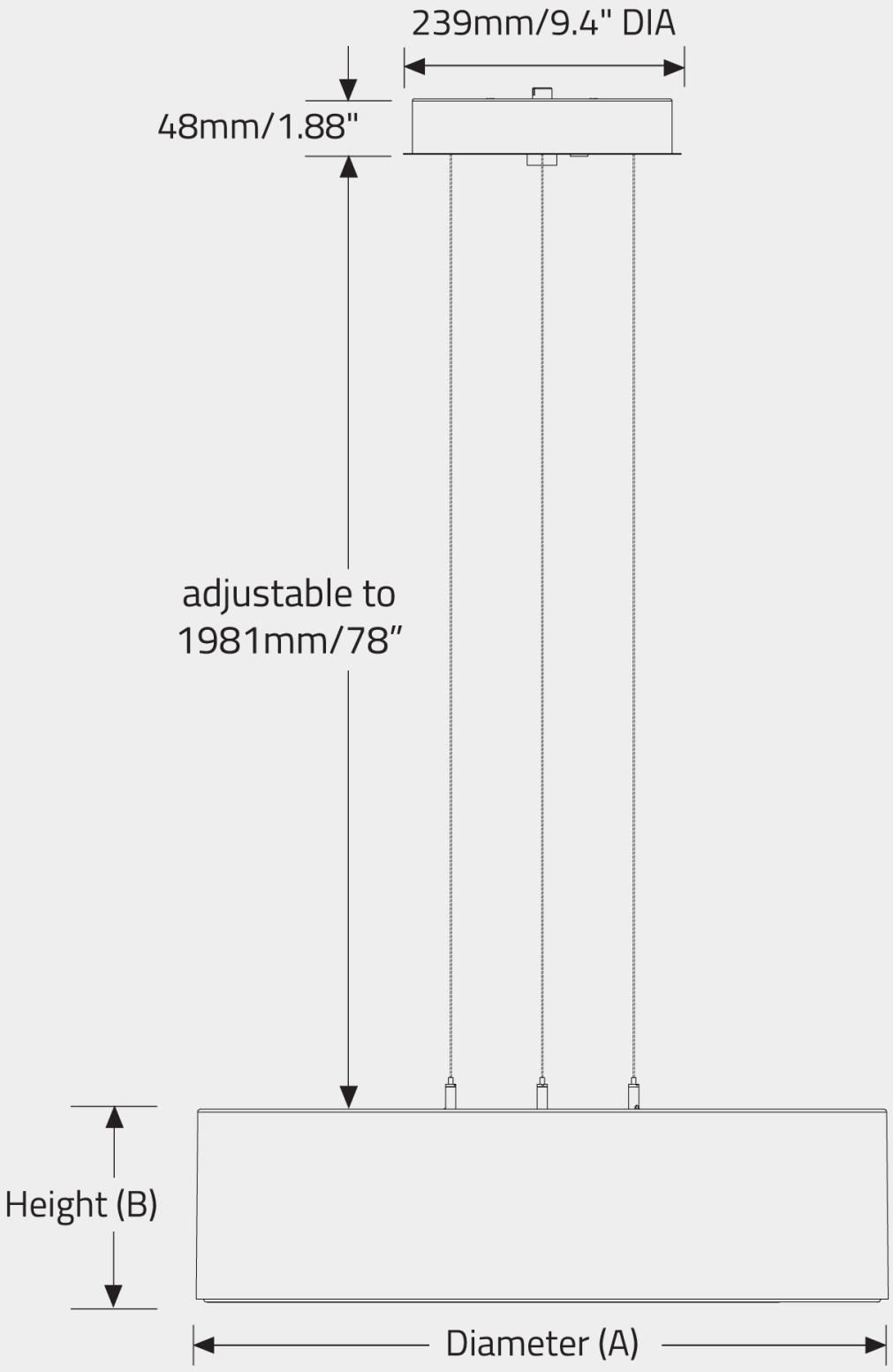
BX0	Downlight not required
BX1	Downlight 28W, 2700K (1730 delivered lms)
BX2	Downlight 28W, 3000K (1799 delivered lms)
BX3	Downlight 28W, 3500K (1854 delivered lms)
BX4	Downlight 28W, 4000K (1858 delivered lms)

Additional Information

Downlight is wired for a separate circuit.

DIMENSIONAL DIAGRAMS

test



Voilà

4" Cylinder Pendant

LUMENWERX

Luminaire **PC**
Option 1
Service desks pendant

CHROMAWERX

Aperture Size

4" (Round)

Baffle Position

Flush, ½" & 1" regress baffles

Height

9"

Mounting Types

Pendant

Cylinder & Cuboid Finishes

Textured matte white
Textured matte black
Custom RAL

Voila 4" Cylinders feature innovative Hyflex™ optics for precise beam control. Voila Cylinders are offered in round and square form factor and 9" height, all with on-board and remote driver options. The Voila COB source matches other Lumenwerx luminaires, with 90 CRI and 2-step color consistency, and is available with ChromaWerx SOLA and DUO. Complete Voila offering includes 2" and 4" apertures; downlights, adjustables, and wall washers; round and square trim; and cylinders.

Performance

LUMEN OUTPUT [1]	WATTS	EFFICACY LM/W
1501 lm	14 W	107 lm/W
2037 lm	20 W	102 lm/W
2744 lm	28 W	98 lm/W

[1] Lumens packages are assuming 3500K, 80 vCRI, 30° beam, round white baffle

Delivered Lumens for Round White Flush (1P) Baffles at 35K

CRI	90 CRI							
BEAM	10	20	30	40	50	60	75	90
Low - 13.8 W	1257	1203	1410	1424	1379	1363	1333	1302
Medium - 19.7 W	1576	1508	1912	1933	1871	1849	1808	1766
High - 28 W	1932	1848	2576	2604	2520	2492	2436	2380

3737 Cote Vertu St-Laurent, Quebec, Canada H4R 2C9
T (514) 225-4304 F (514) 931 -4862
www.lumenwerx.com

Intertek

VOILA4-CYLINDER-PENDANT-SPEC - REV5 - April 3, 2020

Voilà

4" Cylinder Pendant

LUMENWERX

Cylinder

Product Specification

LUMINAIRE ID	CYLINDER		BAFFLE		LENS
VO4CYP	**9**				

VO4CYP - Voila 4" cylinder pendant	**LENGTH** **9** - 9"	**FINISH** **TMW** - Textured matte white **TMB** - Textured matte black **CF#** - Custom finish specify RAL#. (e.g. **CFRAL1028**)	**POSITION** **1P** - Flush **2P** - ½" [2] **3P** - 1" [2] [2] Only available with 50° beam or lower	**FINISH** **TMW** - Textured matte white **TMB** - Textured matte black **CF#** - Custom finish specify RAL#. (e.g. **CFRAL1028**)	**SDL** - Soft diffused lens **FDL** - Frosted diffused lens **NOL** - No lens

Light Element

LIGHT SOURCE	BEAM	COLOR QUALITY	CRI [3]	COLOR TEMP	OPTION
SW - Static white	**10** - 10° Narrow spot **20** - 20° Spot **30** - 30° Narrow flood **40** - 40° Flood **50** - 50° Wide flood **60** - 60° Very wide flood **75** - 75° Very wide flood **90** - 90° Open flood	**2** - 2 Step MacAdam Ellipse	**90** - 90 CRI **80** - 80 CRI **97** - 97 CRI (Not available for 3500K) [3] For ½" and 1" baffle position, please consult factory	**27** - 2700K **30** - 3000K **35** - 3500K **40** - 4000K	**HEX** - Hex louver
SOLA - Dim to warm **DUO** - Tunable white	**20** - 20° Spot **40** - 40° Flood **50** - 50° Wide flood **60** - 60° Very wide flood **75** - 75° Very wide flood **90** - 90° Open flood	**3** - 3 Step MacAdam Ellipse	**90** - 90 CRI (SOLA and DUO)	**SOLA** - Dim to warm 22K-35K **DUO** - Tunable white 27K-65K	

Power Supply & Dimming

VOLTAGE	WATTAGE OPTIONS (80 CRI) [4]	DIMMING OPTIONS	
		INTEGRAL [5]	**REMOTE**
120 - 120V **277** - 277V **UNV** - 120V-277V **347** - 347V (Consult factory)	**14W** - Low output 1294-1532 lm **20W**- Medium output 1623-2078 lm **28W** - High output 1988-2800 lm [4] For delivered lumens, see multiplier tables on page 3	**D1** - 1% 0-10V **ELV** - ELV 120V **TRI** - TRIAC 120V [5] All integral drivers can be used as remote drivers. If chosen as remote, the codes would become **RD1**, **RELV** and **RTRI**.	**RDA** - DALI **RLTEA2W** - Lutron 1% - 2 wire FP 120V **RLDE1** - Lutron Hi-lume 1% Eco **RLDE5** - Lutron 5% EcoSystem **RELD0** - eldoLED 1% **RELD1** - eldoLED 0.1% **+EB** - Emergency battery [6] [6] For emergency battery, code will be like the following example: **RD1 + EB**
	SOLA **13W** - 20° only (920 lm) **25W** - 40° and up (1800-1981 lm) **DUO** **10W** - 20° only (700 lm) **20W** - 40° and up (1100-1200 lm)		**SOLA** **R0-10V** - Single 0-10V input **DUO** **RDMX** - To specify, see pages 6 to 8 **RDA** - DALI **R0-10V** - Dual O-10V input for CCT/intensity

Mounting

CANOPY		HANGER	
TYPE	**FINISH**	**POWER CORD**	**STEM**
REG - Regular canopy, 4" octagonal junction box, round canopy **CD** - Conduit feed, round canopy	**TMW** - Textured matte white **TMB** - Textured matte black **CF#** - Custom finish specify RAL#. (e.g. **CFRAL1028**)	**BPC##** - Black PVC **WPC##** - White PVC **FRE##** - Red fabric **FGR##** - Green fabric **FBL##** - Blue fabric Min 18" - max 72" Please specify length in place of **#**. (e.g. **FBL18**)	**BKS##** - Textured black Stem **WHS##** - Textured white Stem Min 18" - max 36" Please specify length in place of **#**. (e.g. **BKS18**)

3737 Cote Vertu St-Laurent, Quebec, Canada H4R 2C9
T (514) 225-4304 F (514) 931 -4862
www.lumenwerx.com

Intertek

Voilà

4" Cylinder Pendant

Technical Specification

DESCRIPTION Ø 4", 9" long cuboid with multiple output, color, and dimming options in a variety of standard or custom finishes.

CYLINDER
Die-cast and extruded aluminum.
Power Cord: Black and white PVC, red, green and blue fabric. 18" to 72" standard length.
Stem: Rigid stem 18" to 36" standard length
Canopy: Regular and conduit (when recessed wiring is not possible).
Finish: Powder coated paint, textured white & black matte. Custom colors also available (provide RAL #)

FIELD REPLACEABLE LIGHT ELEMENT
LED Module: Integral COB module. 90 CRI and 2 SDCM, Standard with options of 80 CRI, or 97 CRI. L80 > 60,000 hours
Light Output: From 1294-2800 lumens
HyFlex™ Optics: Proprietary TIR/reflector with field interchangeable beam smoothing lenses.
Thermal Management: Cold-forged aluminum heat sink to maximize thermal dissipation.

BAFFLE
Die-cast aluminum
Baffle position: Flush, ½" and 1" regress

CHROMAWERX SOLA (Dim to warm) and DUO (Tunable white). See page 5 for more information.

ELECTRICAL
Integral: 0-10V, ELV, TRIAC
Remote: Lutron Eco-System, Lutron Hi-lume, DALI, eldoLED 0.1%, eldoLED 1%, DMX, Lutron T-Series (Tunable white).
Emergency Options: Remote: Bodine, IOTA and Fulham battery back-up.

ENVIRONMENT Ambient temperature at fixture location shall be within 0°C/32°F - 25°C/77°F, indoor dry or damp as well as outdoor damp use (canopies or marquees).

LISTING cETLus listed to UL 1598 and CAN/CSA Standard C22.2 No. 250.0

WARRANTY 5 year limited warranty on LED module and power supply. Guaranteed to maintain 70% lumen maintenance.

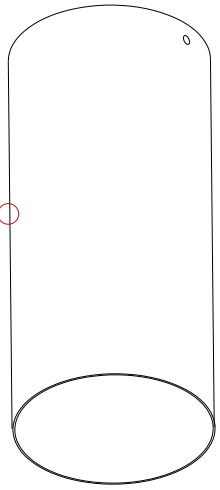
Light

Mounting

Stem Min 18" - Max 36"
PVC Power Cord - Black, White
Fabric Covered Power Cord - Red, Green, Blue [7]
[7] Min 18" - Max 72"

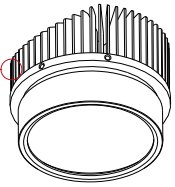
Cylinder Housing

9" Height
Textured Matte White Finish
Textured Matte Black Finish
Custom Finish Specify RAL#



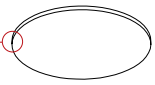
Light Element

Heat Sink
LED Module
Hyflex™ Optics
8 Available Beam Options
10° - 90°



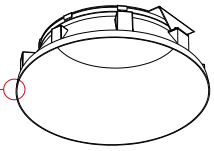
Lens

Frosted
Soft Diffused



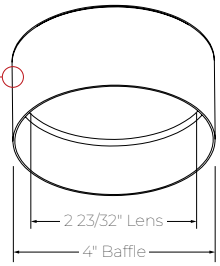
Baffle

3 Baffle Positions - Flush, ½", and 1"
Textured Matte White Finish
Textured Matte Black Finish
Custom Finish specify RAL#



Baffle Cover

Textured Matte White Finish
Textured Matte Black Finish
Custom Finish Specify RAL#



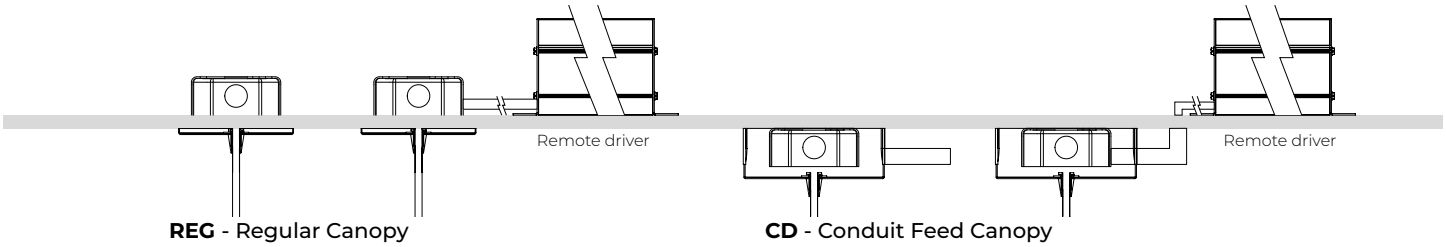
3737 Cote Vertu St-Laurent, Quebec, Canada H4R 2C9
T (514) 225-4304 F (514) 931 -4862
www.lumenwerx.com

VOILA4-CYLINDER-PENDANT-SPEC - REV5 - April 3, 2020

Voilà

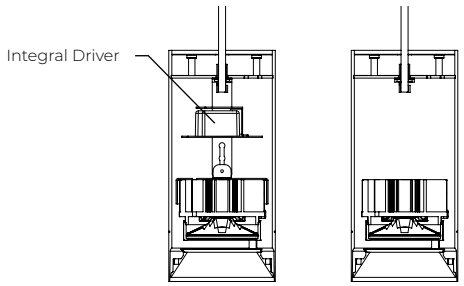
4" Cylinder Pendant

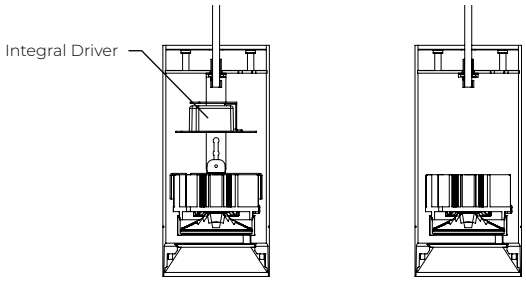
Mounting



REG - Regular Canopy
Integral or remote driver
Round canopy Ø 4 ½"
Height 0.275"

CD - Conduit Feed Canopy
Integral or remote driver
For concrete ceiling
Round canopy Ø 5 ½"
Height 2"





Drawings shown
with power cord.
Stem option available.

Power Cord - Ø ½"
Min 18" - max 72"

Stem
Min 18" - max 36"

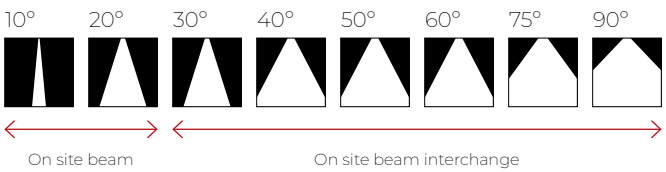
Optics

Hyflex™ optics provide precise optical control in a remarkably compact form.
The core of this four-tier system is compound reflector with a central TIR element, just 1.06" deep.
Beam-smoothing discs perfect beam angles up to 90°. Beam angles are easily interchanged in the field.

Light Source - LED

Compact COB (Chip-On-Board) LED module, available in 2700K, 3000K, 3500K and 4000K with a choice of 80 CRI or 90 CRI with elevated R9 value (for 97 CRI, consult factory). Color consistency is maintained to within 2 SDCM. All LEDs have been tested in accordance with IESNA LM-80-08 and the results have shown L80 lumen maintenance greater than 60,000 hours. Absolute product photometry is measured and presented in accordance with IESNA LM-79, unless otherwise indicated.

Beam Angles



CHROMAWERX

ChromaWerx SOLA is single-channel control that dims output while warming the color temperature in a pre-determined relationship. A simple or analog control adjusts a specially populated LED array to emulate the effect of dimming a filament source.

CHROMAWERX

ChromaWerx DUO offers a two-channel control system which uses analog or digital protocols for synchronous control of both warm (2700K) to cool (6500K) LED arrays - maintaining a CRI above 90. The range of color DUO offers is useful for entraining circadian rhythms, stimulating alertness, and compensating for jet lag among other applications. The ChromaWerx drivers are programmed to limit maximum light output and power usage across all color temperatures.

3737 Cote Vertu St-Laurent, Quebec, Canada H4R 2C9
T (514) 225-4304 F (514) 931 -4862
www.lumenwerx.com

VOILA4-CYLINDER-PENDANT-SPEC - REV5 - April 3, 2020

LIGHTOLIER
by signify

Luminaire **PC**
Options 2
Service desks pendant

Two-piece cast and machined aluminum outer housing contains electrical components. Hand-blown triplex glass provides an even spread of illumination along the length of the primary glass element.

Complete luminaire = Power Head + Glass Element + Suspension Kit

Option 2

Option 3

Power Head

Series	Wattage	Source	CCT	Finish	Voltage
PS	01	LW		SA	U
PS Decorative Pendant	**01** 8W	**LW** LED	**27** 2700K **30** 3000K **35** 3500K **40** 4000K	**SA** Satin Aluminum	**U** Universal 120V/277V

Glass Element

Series
SG03L
SG03L 5 1/2" Opal Glass (required for all glass options)

Complete LED fixture consists of **Power Head** + **Glass Element** + **Suspension Kit**.

Suspension Kits

Featuring fixture matching Satin Aluminum finish.

Series

Clear jacketed steel braided power cord, metal aircraft cable and matching canopy.

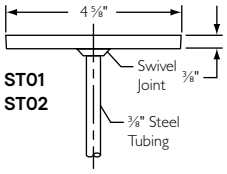
SK01 Cable/Cord kit - Includes 3 solid aluminum lobster claws to neatly secure the steel jacketed power cord to the aircraft cable (10ft. length).

SK02 Cable/Cord kit - Includes 4 solid aluminum lobster claws to neatly secure the steel jacketed power cord to the aircraft cable (25ft. length).

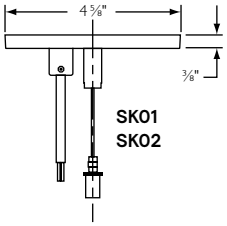
ST01 Stem kit - Stem with matching canopy (3ft. length, 3/8" dia.).

ST02 Stem kit - Stem with matching canopy (5ft. length, 3/8" dia.).

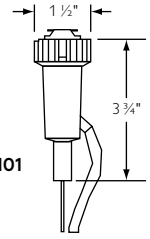
TM01 Track Mounting Kit - Mounts to Lightolier Lytespan Track and includes clear jacketed steel braided power cord and metal aircraft cable (10ft. length).



ST01
ST02



SK01
SK02



TM01

PS Vetro Pendants (conical)

15 1/8" & 17 1/8" decorative luminaire

Features

1. **Power Head:** Comprised of die-cast and extruded aluminum components with a brushed clear lacquer finish.
2. **Backplate:** Die Cast Aluminum, Brushed and Clear Lacquer Finish.
3. **Element:** a primary diffuser comprised of Triplex hand blown glass (PG01) or opal acrylic (PA01).
4. **Luminaire Mounting:** Luminaire can be suspended from ceiling using clear metallic straight cord/cable with canopy (SK01/SK02), stem with canopy (ST01/ST02), close-to-ceiling (CTC) or track mounting (TM01) suspension kits.

Electrical

Dimming: All configurations are non-dimmable.

LED Board: Array of high brightness white LEDs.

LED Thermal Management: Heat sink design maintains junction temperature for consistent, reliable performance and 50,000 hour lifetime at 70% lumen maintenance.

Labels

cULus Listed.
Suitable for damp locations.

Lamping

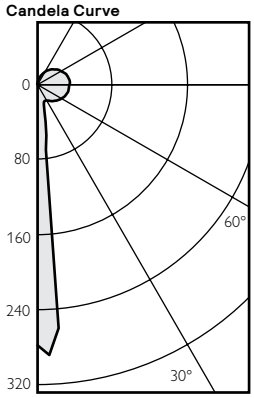
LED: 8W Max.

Input Voltage	Input Frequency	LED Drive Current	Input Power	Power Factor
120-277V	50/60Hz	350mA	8W	>0.9

PS01LW30SAU
SG03L

PS01LW30SAU w/SG03L (with or without GLS02), 8W, 400lms

Candela Curve



Report[1]: 208GFR

Output Lumens:	356lms
Input Watts[2]:	7.5W
Efficacy:	47.5lm/w
CCT[3]:	3000K
CRI:	>80 (min)

Zonal lumens & percentages

Zone	Lumens	%Luminaire
0-30	32	9%
0-40	45	13%
0-60	90	25%
0-90	194	54%
90-180	162	46%
0-180	356	100%

Candela Array		Vertical Angles	
Angle	Mean CP	Angle	Mean CP
0	278	90	34
5	261	95	34
10	56	100	34
15	29	105	33
20	21	110	32
25	19	115	30
30	20	120	28
35	21	125	27
40	23	130	25
45	25	135	23
50	27	140	21
55	29	145	18
60	30	150	15
65	31	155	12
70	33	160	8
75	34	165	4
80	34	170	1
85	34	175	0

Coefficients of utilization

Ceiling	80%			70%			50%			0%
Wall	70	50	10	70	50	10	50	30	10	0
Room Cavity Ratio 0	108	108	108	101	101	101	86	86	86	54
1	94	88	82	87	81	76	69	65	61	37
2	84	75	67	77	69	62	58	52	47	28
3	76	64	55	70	59	51	50	44	38	22
4	69	57	47	64	52	44	44	37	32	18
5	63	50	41	58	46	38	39	32	27	15
6	58	45	36	53	41	33	35	28	24	13
7	54	40	31	49	37	29	32	25	20	11
8	50	37	28	46	34	26	29	23	18	10
9	47	34	25	43	31	24	21	21	16	9
10	43	31	23	40	29	22	19	19	15	8

Zonal cavity method - Effective floor reflect. = 20%

1. Tested using absolute photometry as specified in LM79: IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products. Luminaire with glass tested by relative photometric method.
2. Wattage: controlled to within 5%
3. Correlated Color Temperature: within specs as defined in ANSI_NEMA_ANSLG C78.377-20 08: Specifications for the Chromaticity of Solid State Lighting Products.

Signify North America Corporation
200 Franklin Square Drive,
Somerset, NJ 08873
Telephone 855-486-2216

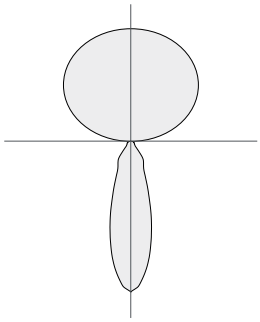
Signify Canada Ltd.
281 Hillmount Road,
Markham, ON, Canada L6C 2S3
Telephone 800-668-9008

Luminaire **PC**
Option 3
Service desks pendant

CONCENTRIC LAYERS OF LIGHT WITH FROSTED AND CLEAR GLASS EFFECT

CYLINDER DISTRIBUTION

	INDIRECT	*DIRECT*
Lumen Range:	750-3000 lm	600-3000 lm
Efficacy Range:	99-109 lm/W	78-92 lm/W
CRI:	82 typ / 80 min	82 typ / 80 min
CCT:	30K / 35K / 40K	30K / 35K / 40K
Beam Angle (FWHM):		31°



CYLINDER

Inde-Pendant 32L-C

The Inde-Pendants Cylinder provides the option of direct and indirect/direct light

CYLINDER OUTPUT

Indirect: 750 lumens → 3000 lumens

Direct: 600 lumens → 3000 lumens

Specifiable in 50 lumen increments

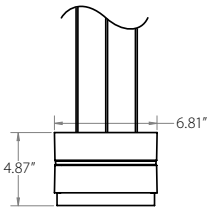
LITECONTROL 32L-C-P-ID
making light work™

Inde-Pendant Pendant Indirect/Direct

Ordering Guide

Feature	Code	Options	Description
Series		32L	Inde-Pendant
Configuration		C	Cylinder
Mounting		P	Pendant
Fixture distribution		ID	Indirect/Direct
Primary Finish		C1 C4 C5 CC	Matte White (Default) Machined Aluminum Carbon Black Custom Color
Accent Finish		/AC1 /AC4 /AC5 /ACC	Matte Finish (Default) Machined Aluminum Carbon Black Custom Color
Color temperature		30K 35K 40K	3000K 3500K 4000K
Cylinder Indirect Output *(specifiable in 50 lumens increments)*		I075 I300	750 3000
Cylinder Direct Output *(specifiable in 50 lumens increments)*		D060 D300	600 3000
Driver		NDM D01 DALI	Non Dimming 1% Dimming, 0-10V DALI
Circuiting		2C	2 Circuit *See 32L Installation instructions for wiring options to address Nightlight and Single Circuiting options available
Voltage		UNV 347	Universal Voltage (120-277) 347 Volt* *Excludes DALI Dimming Option
Ceiling Type		GDW PT OC	Grid or Drywall (Default) Plaster Trim Open Ceiling
Suspension kit		FA5 FA6 FA7	Suspension Kit, 48" (Default) Suspension Kit, 120" Suspension Kit, 240"
Canopy Color		/C1 /C4 /C5 /CC	Matte White (Default) Machined Aluminum Carbon Black Custom Color

Optional Features	Code	Options	Description
Chicago Environmental Air Modification		CCEA	Chicago Environmental Air Modification



Key Features

- Variable Intensity technology provides specifiable lumen output/wattage
- 2.5 SDCM color variation
- Remote-mounted driver assembly
- Customizable finish variations

65 Spring Street Plympton, MA 02367 / Tel **781.294.0100** / Website **www.litecontrol.com**

HUBBELL Lighting

MICRO RING II

Luminaire **PD**
Option 1
Pendants at Public Entrance & Lobby

WEB PIN 181

GENERAL SPECIFICATION

Body: Aluminum.

Finish: Powder coated for standard finishes (black, Silver Metallic & white). For wood grain finishes, the canopy will be white.

Suspension: Stainless steel cables. Power over aircraft cable option (S6) available on direct versions only up to 1524mm/60" diameter (North America only).

Power cable: Silver braided.

Diffuser: Protruding Lens (2.1mm/0.08")

Drivers: HPF electronic drivers for 120-277V (EU-240V).

Remote Mounting of Drivers: Wire size 18 AWG - max distance (from fixture to drivers) 40', wire size 16 AWG - max distance 60', wire size 14 AWG - max distance 90'. Drivers must be accessible after installation.

Remote Emergency: Emergency option provides a 1.5 hour (3 hours for EU) emergency lighting facility. The remote system includes the inverter module, NiCad batteries and a remote wall/ceiling LED charge indicator and test switch (NA only) Maximum distance between wall/ceiling plate and luminaire is 4.5m/15'. Test switch fits a single gang box (not supplied).

Mechanical: Luminaires mount directly over J box (by others - North America only).

L70 @25deg C: > 60,000 hrs.

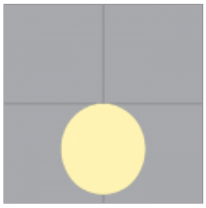
Delivered Lumens: Delivered lumens & LPW based on 4000K (min 80 CRI) for White LEDs only.

Approvals: Damp Location (Indoor use only).

MOUNTING & OPTICS

Suspended Direct

Suspended Direct/Indirect



Direct

Direct-indirect

MICRO RING II

WEB PIN 181

HOW TO ORDER

A SPECIFY LUMINAIRE

Code	Diameter (A)	Light Direction	Power (LED)	Delivered lms	LPW	# of Sections	Suspension Points
95 3005	24"	Direct	21W	2163	104	1	3
95 3010	36"	Direct	31W	3234	104	1	3
95 3020	48"	Direct	40W	4147	104	1	3
95 3030	60"	Direct	54W	5624	104	1	3
95 3040	72"	Direct	64W	6633	104	1	4
95 3050	84"	Direct	76W	7874	104	1	4
95 3105	24"	Direct/Indirect	43W	4482	105	1	3
95 3110	36"	Direct/Indirect	64W	6719	105	1	3
95 3120	48"	Direct/Indirect	86W	9064	105	1	3
95 3130	60"	Direct/Indirect	108W	11350	105	1	3
95 3140	72"	Direct/Indirect	128W	13440	105	1	4
95 3150	84"	Direct/Indirect	152W	15924	105	1	4

B SPECIFY CCT/COLOR (DIRECT)

D30	3000K (min 80 CRI)
D3090	3000K (min 90 CRI)
D35	3500K (min 80 CRI)
D3590	3500K (min 90 CRI)
D40	4000K (min 80 CRI)
D4090	4000K (min 90 CRI)
DRD	Red
DGN	Green
DBL	Blue

C SPECIFY CCT/COLOR (INDIRECT)

N30	3000K (min 80 CRI)
N3090	3000K (min 90 CRI)
N35	3500K (min 80 CRI)
N3590	3500K (min 90 CRI)
N40	4000K (min 80 CRI)
N4090	4000K (min 90 CRI)
NRD	Red
NGN	Green
NBL	Blue

D SPECIFY SUSPENSION

S1	Vertical, Remote Driver
S2	Hub, Remote Driver
S3	Vertical, Integral Driver
S4	Hub, Integral Driver
S6	Power Over Cable, Vertical, Remote Driver (Direct only, max 1524mm/60" dia., 72" suspension max, North America only)

Additional Information

Direct Only light distribution not available with S2 or S4 suspension for size 1829mm/72" and larger. S6 available up to 1524mm/60" diameter and North America only.

Direct/Indirect light distribution not available with S2, S3 or S4 suspension for size 1829mm/72" and larger. S6 is not available with direct/indirect.

E SPECIFY DIMMING (REMOTE ONLY)

D1	0-10V Dimming 1.0%
D4	DALI Dimming 0.1%
D5	DALI Dimming 1.0%

Additional Information

D4 & D5 not available with 953140 or 953150

F SPECIFY FINISH

BL	Black
MS	Silver Metallic
WH	White
Z1	Wood Grain - Light Cherry (36" to 72" dia. only)
Z2	Wood Grain - Dark Walnut (36" to 72" dia. only)

Additional Information

Note: *Canopies for wood grain finishes Z1 & Z2 will be white, and the wood grain finishes are not available for 2134mm/84" diameter.*

G SPECIFY LUMEN & WATTAGE REDUCTION

PR0	Lumen & Wattage Reduction to approximately 25% of standard output
PR1	Lumen & Wattage Reduction to approximately 50% of standard output
PR2	Lumen & Wattage Reduction to approximately 75% of standard output

Additional Information

Note: Custom Reduction Percentages Available Upon Request.

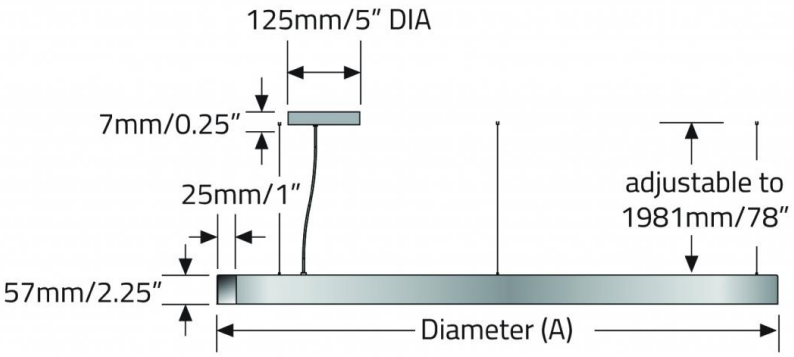
H SPECIFY OPTIONS

RE	Remote Emergency System
SS	Separate switching

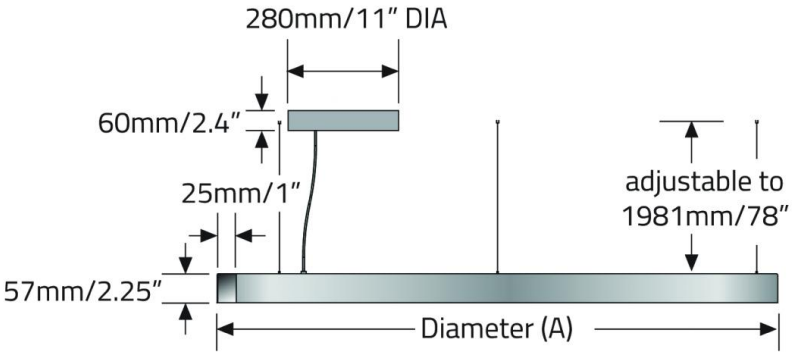
EXAMPLE CODE

953110/35/D35/NGN/S1/WH

S1 VERTICAL - REMOTE DRIVER

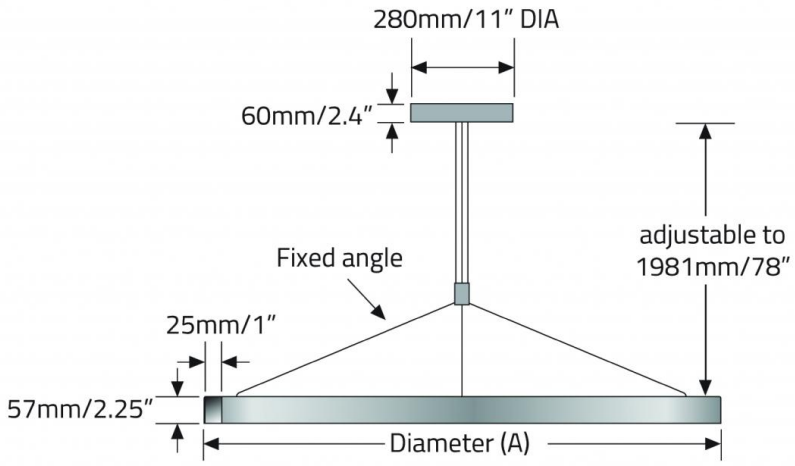


S3 VERTICAL - INTEGRAL DRIVER



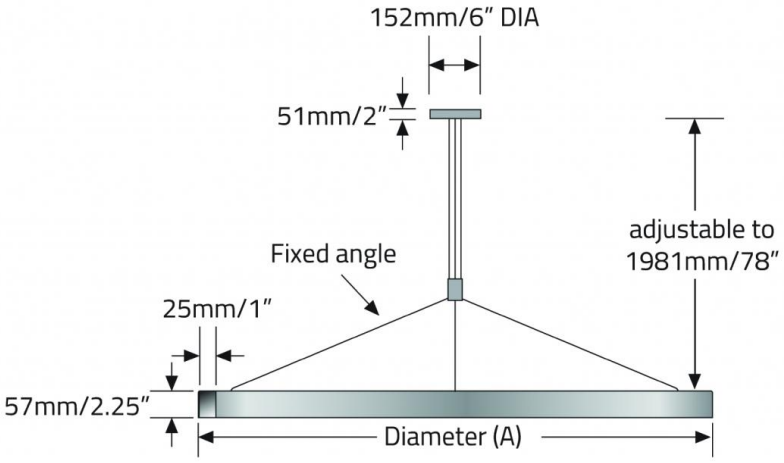
Direct/Indirect: Available up to 1520mm/60" DIA only.

S2 HUB - REMOTE DRIVER



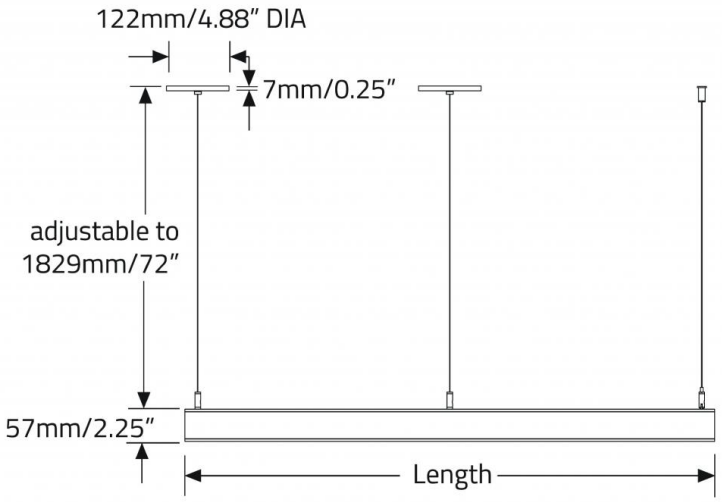
Direct: Available up to 1520mm/60" DIA only.
Direct/Indirect: Available up to 1520mm/60" DIA only.

S4 HUB - INTEGRAL DRIVER



Direct: Available up to 1520mm/60" DIA only.
Direct/Indirect: Available up to 1520mm/60" DIA only.

S6 VERTICAL - REMOTE DRIVER



Power Over Aircraft Cable

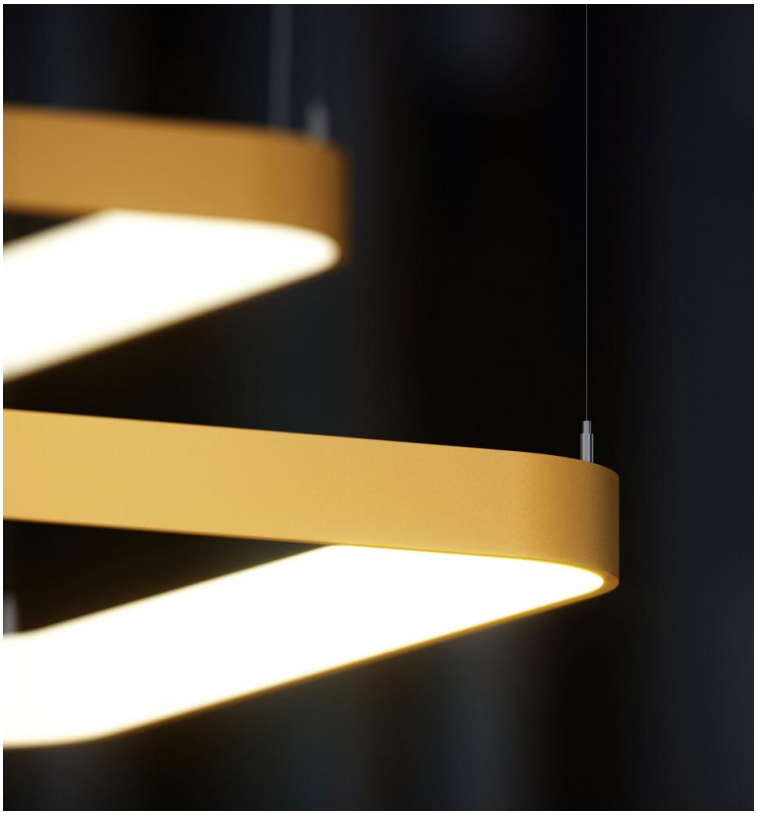
Direct: Available up to 1520mm/60" DIA only (North America only)

SOFT SQ

Luminaire **PD**
Option 2
Pendants at Public Entrance & Lobby

WEB PIN 251

betacalco.com
+1 416-531-9942 | sales@betacalco.com



GENERAL SPECIFICATION

Product Overview:

The optically engineered diffuser throws the light downwards exactly where it is required, whilst creating a subtle indirect glow on the ceiling. Ideally suited for atriums, lobbies, boardrooms and reception areas.

Body: Aluminum and steel.

Diffuser: Opal acrylic.

Drivers: HPF electronic for 120-277V (EU-240V)

Remote mounting of drivers: Wire Size (max distance from canopy to drivers) 18 AWG - 9.5' (2.9m), 16 AWG - 19.5' (5.9m), 14 AWG - 29.5' (9m). Drivers must be accessible after installation.

Remote emergency: Emergency option provides a 1.5 hour (3 hours for EU) emergency lighting facility. The remote system includes the inverter module, NiCad batteries and a remote wall/ceiling LED charge indicator and test switch (NA only) Maximum distance between wall/ceiling plate and luminaire is 25' (7.6m). Test switch fits a single gang box (not supplied).

L70 @25°C: > 50,000 hrs.

Delivered lumens: Delivered lumens & LPW based on 4000K, CRI 80+

Approvals: Damp Location (Indoor use only).

NOTE: FTQP1P02 (22") & FTQP1P03 (36") - AVAILABLE TO ACCEPT ORDERS AS OF OCTOBER 1ST, 2020

MOUNTING & OPTICS

Suspended
Direct/Indirect

Direct-indirect

HOW TO ORDER

A SPECIFY LUMINAIRE - * ACCEPTING ORDERS AS OF OCTOBER 1ST, 2020

Code	Square (A)	Max Wattage	Down/Up Ratio	Max Delivered lms	Max LPW
FTQP1P02	22" *	66W	80/20	4500	78
FTQP1P03	36" *	92W	80/20	6300	78
FTQP1P04	48"	158W	80/20	10800	78

Additional Information

All data shown at max output and nominal values.

*** AVAILABLE TO ACCEPT ORDERS AS OF OCTOBER 1ST, 2020**

B SPECIFY LUMENS

LMA0230	2300
LMA0320	3200
LMA0450	4500
LMA0540	5400
LMA0630	6300
LMA1080	10800

Additional Information

Consult website for available lumens/Square (A).

C SPECIFY CRI

CR80	CRI 80+

D SPECIFY CCT

CTA30	3000K
CTA35	3500K
CTA40	4000K

E SPECIFY VOLTAGE

V1	120/277V
V2	240V [1]
V3	347V [2]

Additional Information

[1] Not available in North America

[2] Only available with DA01 dimming

F SPECIFY DIMMING (REMOTE ONLY)

DA01	0-10V Dimming 1.0%
DA02	0-10V Dimming 0.1%
DA20	DALI Dimming 0.1%
DA21	DALI Dimming 1.0%
DA30	DSI/switchDim [1]

Additional Information

[1] Not available in North America

G SPECIFY SUSPENSION

SS2	Vertical, remote driver

H SPECIFY FIXTURE FINISH

FA01	White
FA02	Black Metallic - Textured
FA20	Silver Metallic - Textured
FA25	Gold Metallic
FA27	Wood grain - Light Cherry [1]
FA28	Wood grain - Dark Walnut [1]
FA44	Midnight Blue Metallic - Textured
FA45	Copper Metallic
FA46	Charcoal Metallic - Textured
FA47	Bronze Metallic - Textured
FA52	Champagne Metallic
FA53	Red Metallic - Textured

Additional Information

[1] Longer lead time may apply, consult factory.

I SPECIFY CANOPY FINISH

CF01	White
CF02	Black Metallic - Textured
CF20	Silver Metallic - Textured
CF25	Gold Metallic
CF44	Midnight Blue Metallic - Textured
CF45	Copper Metallic
CF46	Charcoal Metallic - Textured
CF47	Bronze Metallic - Textured
CF52	Champagne Metallic
CF53	Red Metallic - Textured

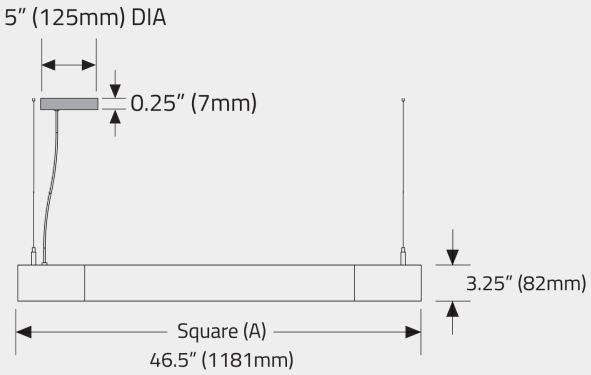
J SPECIFY EMERGENCY

E0	Not required
E2	Emergency system - Remote

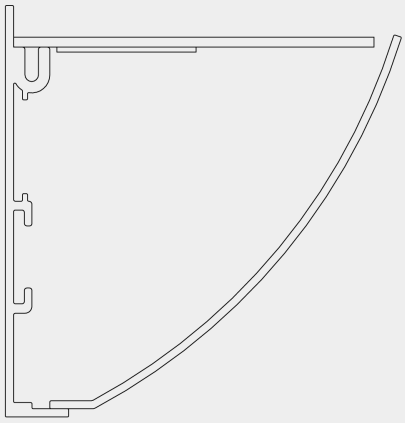
EXAMPLE CODE

FTQP1P04/LMA63/CR80/CTA35/V1/DA01/SS2/FA44/CF01/E0

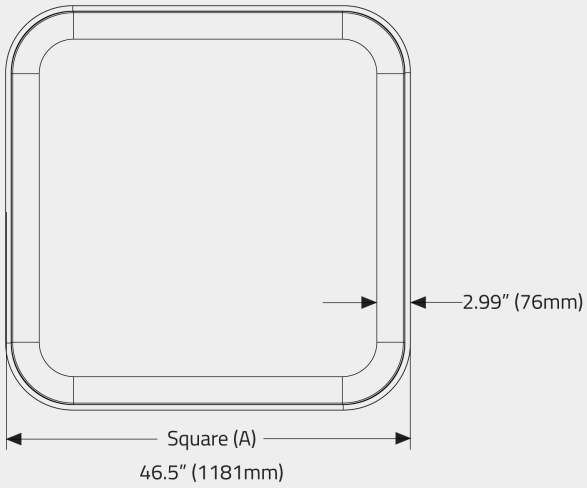
DIMENSIONAL DIAGRAMS



22.4" (569mm) - Available for orders October 2020
36.1" (917mm) - Available for orders October 2020



SECTIONAL VIEW



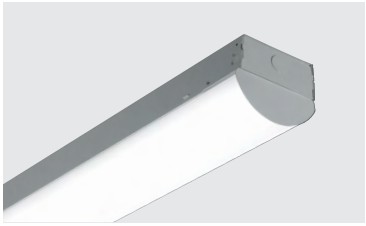
APPROVALS

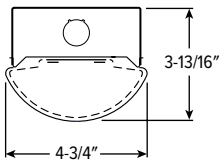
CE DAMP LOCATION ETL Intertek

76R LED Round Lens Strip

Williams

Luminaire PS
Lensed Striplight





FEATURES

- Diffuse acrylic lens enhances uniformity and minimizes glare
- Maximize energy savings with efficacies as high as 154 lm/W
- 40°C max ambient operating temperature
- Diverse selection of mounting accessories for surface and suspended applications
- Channel connector furnished for continuous row applications (included with 8′ units only)
- Special reflectors are available for precise light distribution
- Made Right Here® in the USA

SPECIFICATIONS

- HOUSING – 22-gauge die-formed C.R.S.
- FINISH – 92% minimum average reflective white polyester powder coat bonded to phosphate-free, multi-stage pretreated metal. All parts painted after fabrication to facilitate installation, increase efficiency, and inhibit corrosion.
- SHIELDING – Linear ribbed diffuse acrylic
- ELECTRICAL – High quality mid-power LED boards. L70 at 60,000 hours. 40°C maximum ambient operating temperature.
- MOUNTING – Surface (ceiling or wall) or suspended (hanging hardware required).
- LISTINGS –
  - cETLus conforms to UL STD 1598. Certified to CAN/CSA STD C22.2 No. 250.0. Suitable for damp locations.
- WARRANTY – 5-year limited warranty, see hew.com/warranty.

ORDERING EXAMPLE: 76R - 4 - L52/840 - OPTIONS - DIM - UNV

ORDERING INFO

SERIES	LENGTH [1]	LUMENS [2]	CRI	CCT
76R	**4** 4′	4′	**8** 80	**27** 2700K
	8 8′	**L30** 3,000lm	**9** 90 [6]	**30** 3000K
		L52 5,200lm		**35** 3500K
		L72 7,200lm		**40** 4000K
		L94 9,400lm [4]		**50** 5000K
		8′		
		L60 6,000lm		
		L104 10,400lm		
		L144 14,400lm		
		L188 18,800lm [5]		

OPTIONS [3]

EM/10W	10-watt emergency battery [7]
(L__)	Additional lower lumen packages available.[8] Example: 8,000 nominal lumens = 76R-8-L104/835-**(L80)**
WG-76R11	11-gauge white powder coat wireguard
WG-76R14	14-gauge white powder coat wireguard
SS-12	Single stem and canopy, 12″
SWS-12	Swivel stem and canopy, 12″
GAT	GAT fastener (T-bar clip)
VBY	(2) Y-hangers
VBY-2	(2) Y-hangers and (2) 2′ chains
SMH-76R	Surface mount hanger
SHS-76R	Surface mount hanger for grid ceilings

AIRCRAFT CABLES (EXAMPLE: ACFL/D48) [9]

Prefix		Type	Length
ACFL/	Feeder	**D** 1″ grid & hardpan	**24** 24″
ACJL/	Joiner	**N** 9/16″ grid	**48** 48″
		S Slot grid	**96** 96″

CONTROL [10]

DIM	Dimming driver
DRV	Non-dimming driver
VDO/DSR	Lutron Vive integral fixture control, RF with daylight and occupancy sensor (DFCSJ-OEM-OCC) and sensor-ready driver
VRF/DSR	Lutron Vive integral fixture control, RF only (DFCSJ-OEM-RF) and sensor-ready driver

VOLTAGE

120	120V
277	277V
UNV	120-277V
480	480V with stepdown transformer [11]

NOTES

1. For actual length, see page 3 for FIXTURE DETAILS
2. Lumen output based on 4000 CCT. Actual lumens may vary +/-5%, see page 2 for FIXTURE PERFORMANCE DATA.
3. See page 3 for FINISH OPTIONS. See page 3 for MOUNTING DETAILS. See page 3 for SPECIAL REFLECTOR OPTIONS. See page 3 for QUICK CONNECT OPTIONS.
4. 30°C maximum ambient operating temperature.
5. 30°C maximum ambient operating temperature.
6. Extended lead times may apply. Consult factory for availability.
7. 30° maximum ambient operating temperature
8. Specify in increments of 100 nominal lumens. Option must be specified with next higher lumen package.
9. VBY hanger(s) included. Units specified with aircraft cable require cord. See page 3 for MOUNTING DETAILS.
10. See page 2 for ADDITIONAL CONTROL OPTIONS.
11. Not available with EM drivers

76R LED Round Lens Strip

FIXTURE PERFORMANCE DATA

	LED PACKAGE	DELIVERED LUMENS	WATTAGE	EFFICACY (lm/W)
4'	L30	3067	20.3	150.9
	L52	5261	35.8	146.8
	L72	7212	50.2	143.6
	L94	9418	68.6	137.3
8'	L60	6134	39.8	154.1
	L104	10523	69.5	151.3
	L144	14425	100.5	143.6
	L188	18836	137.1	137.3

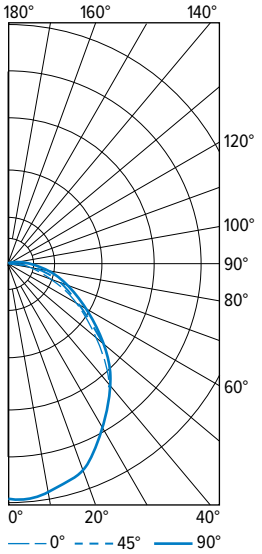
- Photometrics tested in accordance with IESNA LM-79. Results shown are based on 25°C ambient temperature.
- Wattage shown is average for 120V through 277V input.
- Results based on 4000K, 80 CRI, actual lumens may vary +/-5%
- Use multiplier table to calculate additional options.

MULTIPLIER TABLE

	COLOR TEMPERATURE	
	CCT	CONVERSION FACTOR
80 CRI	2700K	0.94
	3000K	0.96
	3500K	0.97
	4000K	1.00
	5000K	1.03
90 CRI	2700K	0.77
	3000K	0.79
	3500K	0.80
	4000K	0.83
	5000K	0.86

PHOTOMETRY

76R-4-L94/840 Total Luminaire Output: 9418 lumens; 68.6 Watts | Efficacy: 137.3 lm/W



CANDLEPOWER DISTRIBUTION	VERTICAL ANGLE	HORIZONTAL ANGLE 0°	45°	90°	ZONAL LUMENS
	0	3041	3041	3041	
	5	3067	3019	3010	288
	15	2910	2905	2926	821
	25	2599	2674	2746	1231
	35	2171	2340	2469	1458
	45	1676	1928	2113	1478
	55	1177	1490	1706	1311
	65	715	1046	1284	1023
	75	358	701	908	711
	85	71	445	633	446
	90	0	347	516	
	95	0	274	442	273
	105	0	166	305	168
	115	0	105	210	102
	125	0	65	141	58
	135	0	41	90	31
	145	0	8	50	13
	155	0	0	37	6
	165	0	0	12	1
	175	0	0	0	0
	180	0	0	0	

LUMEN SUMMARY	ZONE	LUMENS	% FIXTURE
	0 - 30	2339	25
	0 - 40	3798	40
	0 - 60	6586	70
	0 - 90	8766	93
	90 - 120	543	6
	90 - 150	645	7
	90 - 180	652	7
	0 - 180	9418	100

ADDITIONAL CONTROL OPTIONS

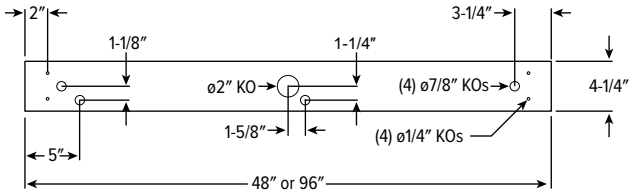
Note: Lumen restrictions apply, consult product builder at hew.com/product-builder.

CATALOG NUMBER	DESCRIPTION
DRV	Driver prewired for non-dimming applications
DIM	Dimming driver prewired for 0-10V low voltage applications
DIM1	1% dimming driver prewired for 0-10V low voltage applications
DIM LINE	Line voltage dimming driver (Must specify 120V or 277V only)
DSR	Sensor-ready driver
SD40	40% step-dimming driver
SD50	50% step-dimming driver
DALI	DALI dimming driver
LTE LINE	Lutron Hi-lume 1% 2-wire dimming driver forward phase line voltage controls (120V only)
LDE1	Lutron Hi-lume 1% EcoSystem dimming LED driver
LDE5	Lutron 5-Series 5% EcoSystem dimming LED driver
VDO/DSR	Lutron Vive integral fixture control, RF with daylight and occupancy sensor (DFCSJ-OEM-OCC) and sensor-ready driver
VRF/DSR	Lutron Vive integral fixture control, RF only (DFCSJ-OEM-RF) and sensor-ready driver
VDO/DBI/LDE1	Lutron Vive integral fixture control, RF with daylight and occupancy sensor (DFCSJ-OEM-OCC), Lutron Hi-lume 1% EcoSystem dimming LED driver, and digital link interface
VDO/DBI/LDE5	Lutron Vive integral fixture control, RF with daylight and occupancy sensor (DFCSJ-OEM-OCC), Lutron 5-Series 5% EcoSystem dimming LED driver, and digital link interface
VRF/DBI/LDE1	Lutron Vive integral fixture control, RF only (DFCSJ-OEM-RF), Lutron Hi-lume 1% EcoSystem dimming LED driver, and digital link interface
VRF/DBI/LDE5	Lutron Vive integral fixture control, RF only (DFCSJ-OEM-RF), Lutron 5-Series 5% EcoSystem dimming LED driver, and digital link interface
ELDO SOLOB	EldoLED Solodrive, 0.1% dimming driver for 0-10V controls
ELDO SOLOB DALI	EldoLED Solodrive, 0.1% dimming driver for DALI controls
ELDO ECO1	EldoLED Ecodrive, 1% dimming driver for 0-10V controls
ELDO ECO1 DALI	EldoLED Ecodrive, 1% dimming driver for DALI controls

76R LED Round Lens Strip

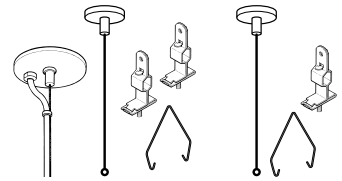
FIXTURE DETAILS

BACKVIEW



MOUNTING DETAILS

STANDARD HARDWARE FOR SUSPENDED PRODUCT (Grid and Hardpan)



Feeder/Stand-Alone

Joiner

Notes:

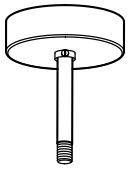
- Fixtures are provided with adjustable length aircraft cables, (2) VBY hangers and mounting hardware, must specify.
- Electrical supply is brought into the feeder fixture, either as part of a row or as a stand-alone unit. Joiner fixtures complete the row.
- The feeder kits are standard with a 5″ canopy to cover the junction box and a 2″ canopy at the non-feed point. No J-box is required at non-feed points.

CORD FOR SUSPENDED PRODUCT

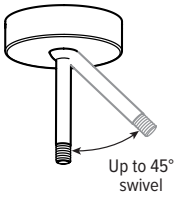
Units specified with aircraft cable require cord. Please specify cord type using ordering information below.

EXAMPLE: S2438/W				
CORD TYPE	LENGTH	# OF COND.	WIRE SIZE	COLOR
S	**24** 24″ **48** 48″ **96** 96″	**3** **4** **5**	**8**	**/W** White **/B** Black

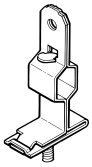
SS-12



SWS-12

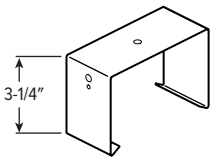


GAT

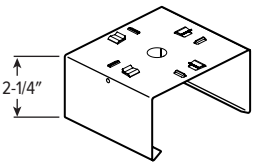


VBY OR VBY 2

SMH-76R

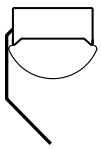


SHS-76

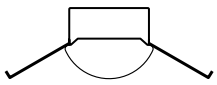


SPECIAL REFLECTOR OPTIONS

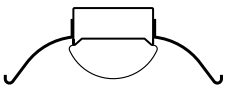
R1015



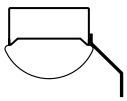
R1172



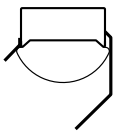
R1240



R1324



R1684



Clear polycarbonate reflector aligners for continuous row applications are supplied with reflectors.

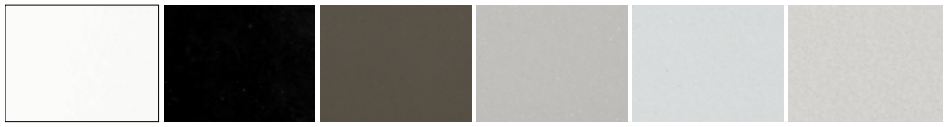
QUICK CONNECT OPTIONS

Note: Quick connect wiring required for row mounting. Length restrictions may apply, consult product builder at hew.com/product-builder.

DESIGNATION	NUMBER OF WIRES (EXCLUDING GROUND)	WIRE COLORS	WIRE COLOR/POWER SUPPLY FACTORY CONNECTIONS	TYPICAL USE
C2B	3	White, Black, Red	White, Black	Alternating Circuits
C2BR	3	White, Black, Red	White, Black, Red	ON/OFF Switching (DRV) or Line Voltage dimming (DIM LINE) when equipped w/EM Power Supply (EM/10W)
C2R	3	White, Black, Red	White, Red	Alternating Circuits
C2BW/RY	5	White, Black, Red, Gray, Green	White, Black/Red, Gray	0-10V 4-wire Low Voltage Dimming (DIM)

FINISH OPTIONS

WHITE BLACK BRONZE NICKEL SILVER ALUMINUM



For custom color, please specify RAL code or a manufacturer code with description. All custom colors other than RAL require two sample swatches, minimum 1″ square.

INTEGRID TRACK (120V) •

Luminaire **TA**
Lighting Track & Fixtures

GENERAL Integrid Track shall be a combination Track and main runner for mechanically supporting suspended ceiling systems. Integrid Track shall allow fixtures to be easily focused, switched, dimmed, accessorized and removed as desired. Integrid Track system shall have a twelve year warranty from date of shipment.

MECHANICAL Integrid Track shall be constructed of .070 (2mm) extruded aluminum with overall height of 2.19 (56mm) and overall track width of 1.812 (46mm) with overall flange to flange width of 2.50 (64mm). Integrid Track shall have the same overall dimensions and physical appearance for both one and two circuit models.

Integrid Track shall be available in 12 foot (3.7m) length, in white high temperature baked paint finish. Integrid Track shall be field cuttable to any length with a single cut.

Integrid Track system shall be available with End Feed, End Cap, Straight Mini-Joiner, and Straight Joiner/Feeder as standard components.

Integrid Track shall have pre-punched 0.25 diameter (6mm) mounting holes on 12 inch (305mm) centers for cable suspension mounting. Universal spring steel Cross Tee Clips (14) shall be supplied with each 12 foot (3.7m) track section. These clips shall accommodate the suspension ceiling system cross tees on any centers for any size ceiling tile.

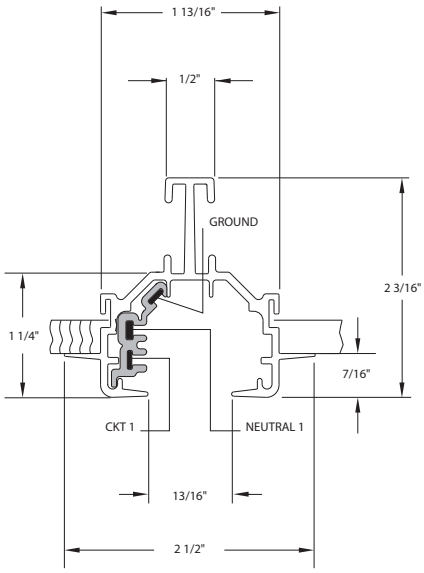
ELECTRICAL Integrid Track and components shall be UL and CUL listed, CE Certified, and comply with the National Electric Code standards for Lighting Track. One and two circuit Integrid Track shall be rated at 120/250 volt, 50/60 Hz, 2400 watts maximum each circuit. Each 20 amp/120 volt circuit shall be comprised of flat copper busbars and have a separate neutral busbar for each circuit busbar. The neutral busbar shall be oversized to be comparable to #10 gauge 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics. A separate grounding busbar shall be integral in all track lengths. All busbars shall be insulated to prevent contact with aluminum extrusion.

Integrid Track shall have electric feed capability through .75 diameter (19mm) 1/2-14NPS threaded hole in both cast alloy End Feed and cast alloy Straight Joiner/Feeder.

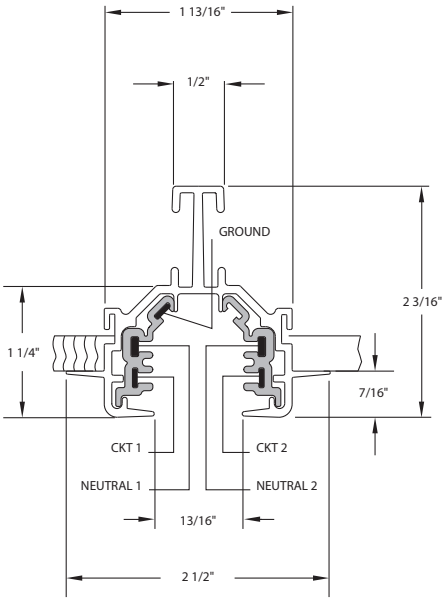
One and two circuit Integrid lighting track with separate neutral busbars shall have the ability to have each circuit separately dimmed as required when using standard voltage and low voltage fixtures with either magnetic or electronic transformers. Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run.

FIXTURE FITTING INTERFACE Integrid Track shall accept only GE fiber reinforced Lexan™ fixture fittings which positively lock into track and cannot be energized by integral switch until safety interlock handle is in the closed position. Safety interlock shall also prevent fixture fitting removal from track unless the switch is in the “off” position. Upon insertion of fixture fitting into track, grounding connection from fixture fitting to track shall be automatically completed before any electrical contact is made with busbars. When removing fixture fitting from track, the grounding connection shall automatically be disconnected last. The fixture fitting shall recess into the track, creating a minimal profile below the track. Fixture fittings for magnetic low voltage fixtures shall be furnished with fuse of the correct ampere rating for integral transformer protection, and shall not be fused as a branch circuit.

One Ckt 120V Integrid Track



Two Ckt 120V Integrid Track

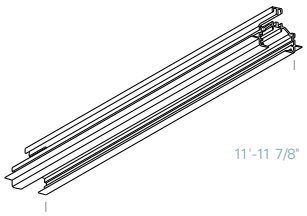


INTEGRID TRACK (120V) • COMPONENTS

Key Features / Applications

UL and CUL listed, CE Certified, Dry Location • IBEW union made at LSI plant in USA • Combination LSI Track and main runner for mechanically supporting suspended ceiling systems of major ceiling manufacturers • Specification grade heavy duty .070 (2mm) extruded aluminum track • 12 foot (3.7m) field cuttable lengths • One circuit 20 amp or two circuit 40 amp capacity/120/250 volt • Copper busbars equivalent to #12 AWG wire used as circuit and ground track conductors • Oversized copper busbars equivalent to #10 AWG wire used as neutral track conductors • Separate copper grounding busbar used throughout track system • White finish • Cast alloy End Feed for power input • Cast alloy Straight Joiner /Feeder for power input and mechanical joining of track lengths • Straight Mini-Joiner for electrically and mechanically coupling track lengths • Combination End Cap/Clip for electrically and mechanically ending the main runner which also aligns the track with the wall or ceiling system as needed • Universal spring steel Cross-Tee Clip allows suspension ceiling cross-tees to be connected anywhere along the track length.

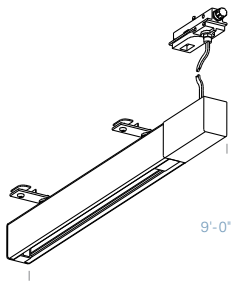
Integrid Track Sections



Integrid Track Sections are used in conjunction with an End Feed, End Cap, Straight Joiners and Straight Mini-Joiners. Integrid Track Section lengths are nominal 12 foot (3.7m) which are field cuttable. Integrid Track Sections have integral extruded fins for supporting ceiling tiles. 14 Cross Tee Clips included with each section of track.

Finish		12 ft
White	One Ckt	**41330**
	Two Ckt	**42330**

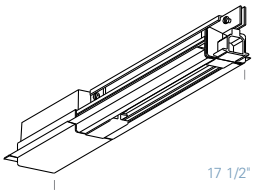
Integrid Bridge Track



Integrid Bridge Track is a complete portable, field cuttable, surface UniTrack system that mechanically and electrically mounts to and spans parallel runs of Integrid Track. Integrid Bridge Track provides an additional range of striking angles for track lighting fixtures or for centering a fixture over a target located between parallel runs of Integrid Track up to 8 foot (2.4m) on center.

Finish		9 ft
White	One Ckt	**31325**

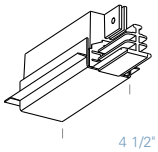
Integrid Security Worklight Track



Integrid Security/Worklight Track is a separately fed one circuit Integrid Track Section, suitable for most LSI track fixtures, that integrates into any LSI Integrid Track run or configuration at any location. Consult fixture cutsheet. LSI fixtures (add suffix EF) mechanically lock into Integrid Security/Worklight Track by means of special hardware and do not have on/off switches.

	All One Ckt		
Finish	18" Joiner Section	18" End Feed Section	18" End Cap Section
White	**41350**	**41351**	**41352**

Integrid End Feed



Integrid End Feed is a cast alloy End Feed with integral fin for supporting ceiling tile and aligning Integrid Track with wall or ceiling system.

Finish		
White	One Ckt	**41300**
	Two Ckt	**42300**

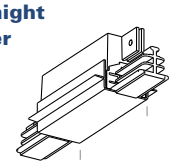
INTEGRID TRACK (120V) • COMPONENTS

Integrid End Cap

Integrid End Cap is a combination End Cap/Clip and is used for mechanically ending any Integrid Track run, and for aligning the Integrid Track with wall or ceiling system.

Finish		
White	One & Two Ckt	**40303**

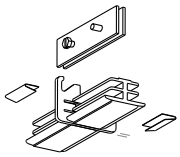
Integrid Straight Joiner/Feeder



Integrid Straight Joiner/Feeder is a cast alloy Straight Joiner for mechanically and electrically coupling any two lengths of Integrid Track.

Finish		
White	One Ckt	**41304**
	Two Ckt	**42304**

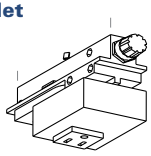
Integrid Straight Mini-Joiner



Integrid Straight Mini-Joiner is used to mechanically and electrically couple any two lengths of track in a straight line. Add .125 (3mm) for Integrid Straight Mini-Joiner when calculating overall lengths of straight runs (overall lengths are not the same as when using Integrid Straight Joiner/Feeder). Not for use as feeder.

Finish		
White	One Ckt	**41311**
	Two Ckt	**42311**

Integrid Track U-Ground Outlet



Integrid Track U-Ground Outlet provides a convenient switched and fused U-Ground receptacle for power and is rated 5A-125V. Non-UL listed.

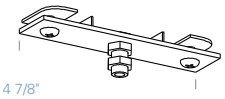
Finish		
Silver	One & Two Ckt	**31160**
Black	One & Two Ckt	**31260**
White	One & Two Ckt	**31360**

Display Hook

Display Hook is used to mechanically hang an item from the Integrid Track without electrifying it. Do not exceed 20 lbs. at minimum spacing of two feet (609mm).

Finish		
Silver	One & Two Ckt	**30761**

Weight Support Bar



Weight Support Bar provides a threaded nipple and nuts to mount an item to Integrid Track without electrifying it. Do not exceed 20 lbs. at minimum spacing of two feet (609mm). Nipple size 1/8-27 NPS (.406 diameter).

Finish		
Silver	One & Two Ckt	**30762**

Track Closure Cover

Field cuttable Noryl Track™ Closure Covers are used to enclose the open face of the track, and simply snap into place.

	Nominal Length
Finish	12 Ft
Silver	**30167**
Black	**30267**
White	**30367**

SURFACE TRACK (120/250V) • SPECIFICATIONS

GENERAL Lighting Track shall allow fixtures to be located anywhere along the track length. Fixtures shall be easily focused, switched, dimmed, accessorized and removed as desired. Track system shall have a twelve year warranty from date of shipment.

MECHANICAL Lighting Track shall be constructed of .070 (2mm) extruded aluminum with overall height of 1.42 (36mm) and overall width of 1.812 (46mm). Track shall have same overall dimensions and physical appearance for both one and two circuit models.

Track shall be available in nominal 4 foot (1.2m), 8 foot (2.4m), and 12 foot (3.7m) lengths, in Silver, Black, and White high temperature baked paint finish. Track shall be field cuttable to any length with a single cut.

Track system shall be available with End Feed, End Cap, Straight Mini-Joiner, Straight Joiner/Feeder, Flexible Joiner and L, T, and X Joiner/Feeders as standard components.

Track shall have the ability to be directly surface mounted. Track shall have pre-punched mounting slots for direct mounting to any surface. Track shall have the ability to: be mounted 1/2 inch (13mm) from a surface by extruded aluminum mounting clips, be suspended from a surface by a field cuttable stainless steel cable system, be suspended from a surface by a field cuttable steel stem system, and be mounted into UniTrack housing.

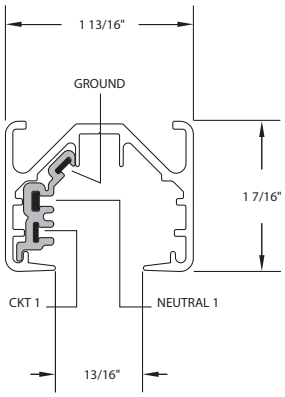
ELECTRICAL Lighting Track and components shall be UL and CUL listed, CE Certified, and comply with the National Electric Code standards for Lighting Track. One and two circuit Lighting Track shall be rated at 120/250 volt, 50/60 Hz. 2400 watts maximum each circuit. Each 20 amp/120 volt circuit shall be comprised of flat copper busbars and have a separate neutral busbar for each circuit busbar. The neutral busbar shall be oversized to be comparable to #10 gauge 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics. **Track shall have integral wiring channels for six (6) additional #12 THHN wires to create three (3) additional 20 amp/120 volt circuits, which can be dropped into any Joiner/Feeder, for a total track power capacity of 100 amps.** A separate grounding busbar shall be integral in all track lengths. All busbars shall be insulated to prevent contact with aluminum extrusion.

Track shall have electric feed capability through all Joiner/Feeders (except Flexible Joiner and Straight Mini-Joiner) using either 1/2 or 3/4 U.S. trade size knock-outs (.875 diameter [22mm] or 1.125 diameter [29mm]). Joiner/Feeders can be electrically field modified by removing the Lexan™ cover and rerouting internal pre-wired jumpers. All Joiner/Feeders shall be available in Black, White, and Silver GE fiber reinforced Lexan™.

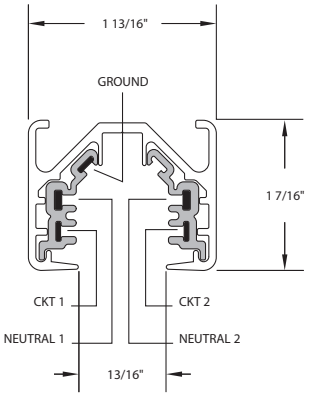
One and two circuit Lighting Track with separate neutral busbars shall have the ability to have each circuit separately dimmed as required when using standard voltage and low voltage fixtures with either magnetic or electronic transformers. Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run.

FIXTURE FITTING INTERFACE Track shall accept GE fiber reinforced Lexan™ fixture fittings which positively lock into track and cannot be energized by the integral switch until safety interlock handle is in the closed position. Safety interlock shall also prevent fixture fitting removal from track unless the switch is in the "off" position. Upon insertion of fixture fitting into track, grounding connection from fixture fitting to track shall be automatically completed before any electrical contact is made with busbars. When removing fixture fitting from track, the grounding connection shall automatically be disconnected last. The fixture fitting shall recess into the track, creating a minimal profile below the track. Fixture fittings for magnetic low voltage fixtures shall be furnished with fuse of the correct ampere rating for integral transformer protection, and shall not be fused as a branch circuit.

One Ckt 120/250V Track



Two Ckt 120/250V Track

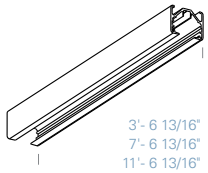


SURFACE TRACK (120/250V) • COMPONENTS

Key Features / Applications

UL and CUL listed, CE Certified, Dry Location • IBEW union made at LSI plant in USA • Specification grade heavy duty .070 (2mm) extruded aluminum track • 4 foot (1.2m), 8 foot (2.4m) and 12 foot (3.7m) field cuttable lengths • One circuit 20 amp or two circuit 40 amp capacity/120/250 volt • 100 amp total capacity when using integral wireways • Copper busbars equivalent to #12 AWG wire used as circuit and ground track conductors • Oversized copper busbars equivalent to #10 AWG wire used as neutral track conductors • Separate neutral track conductor used for each circuit • Separate copper grounding busbar used throughout track system • Black, White, and Silver finishes • All Joiner/Feeders, Flexible Joiners, Mini-Joiners, End Feeds and End Caps are injection molded of GE fiber reinforced Lexan™ • All Joiner/Feeders and Flexible Joiners are prewired and simply couple into track • All Joiner/Feeder circuits can be easily field modified by changing internal jumper wires • Fixture fitting recesses into track for minimum profile • LSI surface track can be mounted directly to any surface 5'-0" above finished floor.

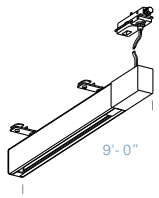
Surface Track Sections



120/250V Surface Track Sections are used in conjunction with an End Feed, End Cap and a variety of Joiner/Feeders to form track runs and configurations. Track Section lengths are nominal 4 foot (1.2m), 8 foot (2.4m) and 12 foot (3.7m) which are field cuttable.

		Nominal Length		
Finish		4 ft	8 ft	12 ft
Silver	One Ckt	31010	31020	31030
	Two Ckt	32010	32020	32030
Black	One Ckt	31210	31220	31230
	Two Ckt	32210	32220	32230
White	One Ckt	31310	31320	31330
	Two Ckt	32310	32320	32330

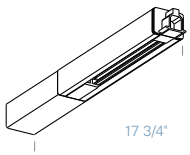
Bridge Track



120/250V Bridge Track is a complete, portable, field cuttable, surface UniTrack system that mechanically and electrically mounts to and spans parallel runs of LSI Track. Bridge Track provides an additional range of striking angles for track lighting fixtures or for centering a fixture over a target located between parallel runs of track up to 8 foot (2.4m) on center.

Finish		9 ft
Silver	One Ckt	31025
Black	One Ckt	31225
White	One Ckt	31325

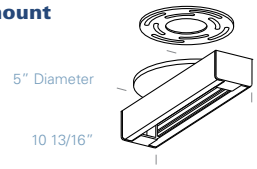
Security/Worklight Track



120/250V Security/Worklight Track is a separately fed one circuit Track Section, suitable for most LSI track fixtures, that integrates into any LSI Track run or configuration at any location. Consult fixture cutsheet. LSI fixtures (add suffix EF) mechanically lock into Security/Worklight Track by means of special hardware and do not have on/off switches.

	All One Ckt			
Finish	18" Joiner Section	18" End Feed Section	18" End Cap Section	18" Conduit End Feed Section
Silver	31050	31051	31052	31053
Black	31250	31251	31252	31253
White	31350	31351	31352	31353

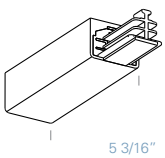
Unimount



120/250V Unimount is a compact canopy mount Track section which will accept most single LSI Track fixtures up to 500 watts.

Finish		
Silver	One Ckt	31161
Black	One Ckt	31261
White	One Ckt	31361

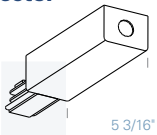
End Feed



120/250V End Feed is used in conjunction with a Canopy Kit for top feeding from a recessed outlet box and can also be top fed directly with cable.

Finish		
Silver	One Ckt	31100
	Two Ckt	32100
Black	One Ckt	31200
	Two Ckt	32200
White	One Ckt	31300
	Two Ckt	32300

End Feed for Conduit Connector



120/250V End Feed for Conduit Connector is used when feeding directly into the end of an End Feed. Connector supplied with 1/2" US trade size hole.

Finish		
Silver	One Ckt	31102
	Two Ckt	32102
Black	One Ckt	31202
	Two Ckt	32202
White	One Ckt	31302
	Two Ckt	32302

LZ 120/277V LED COB

These compact spotlights offer zoom functionality to easily adjust beam spreads from 5° to 50°.

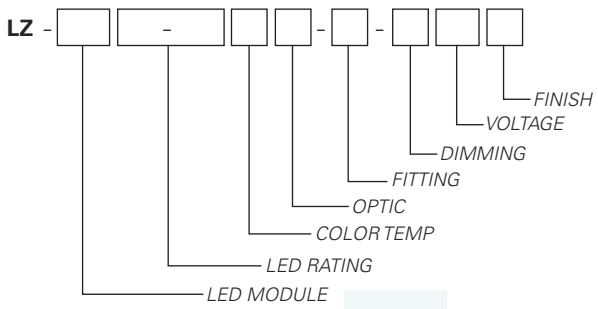
- Adjustable 5°- 50° optic produces up to 30,000 CBCP with 1850 lumens at 20 watts
- System efficiency up to 53 lumens/watt
- Exceeds ANSI specifications by maintaining extremely tight color consistency over the life of the fixture
- Tested to LM79 and LM80 Protocols
- 50,000 hour life to 70% lumen output, L_{70} at 95°F max ambient
- Hidden integral electronic driver, compatible with trailing edge electronic low voltage dimmers (dimmable to 10%)
- Color Rendering Index (CRI) 80, 90
- Color consistency, 2 MacAdam ellipses
- Removable accessory cartridge for any double combination of size-ZM LSI filters and accessories
- No UV or IR emissions; no mercury or lead
- On/off safety switch (on most mounting types)
- Sturdy die-cast aluminum housing
- Integrated latch on barrel to lock focus in place
- Horizontal and vertical aiming is both self and tool-locking via Allen key
- Finishes: LSI Black, White, and Silver
- Fixture weight: 4 lbs

FIXTURE PART NUMBERS

Please review the **ORDERING INFORMATION** section on the next page as well as the **MOUNTING OPTIONS** on page 3 to create a part number for each fixture that specifies the following:

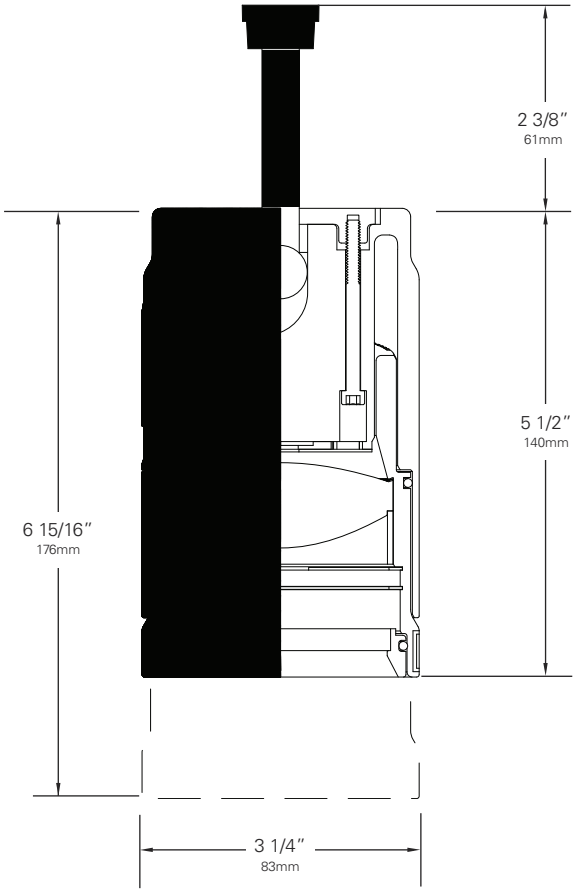
- LED Module
- LED Rating
- Color Temperature
- Optic
- Fitting
- Dimming
- Voltage
- Finish

PART NUMBER



Example Part Number: **LZ-C0619-8030ZM-PT2-TE120W** is a fixture with a single LED module, 1850 Lumen/80 CRI/5 Watt LED rating, 3000°K Color Temperature, 6mm Adjustable Optic, PT2 POWERTrack fitting with Trailing Edge group dimming capability, 120V and a White finish.

LZ 120/277V LED COB



DRIVER TYPE (Electronic)

TE Dimmer	
Input Power (A) - 120V	0.16
Input Power (A) - 277V	0.07
Wattage	20
Power Factor - 115V	0.92

LED ORDERING INFORMATION

Base Fixture Model

☐ LZ-C06 (6mm COB)

LED Rating (Lumens/CRI/Wattage)

☐ 19-80 = 1850/80/20
☐ 15-90 = 1500/90/20

Color Temperature

☐ 27 = 2700K
☐ 30 = 3000K
☐ 35 = 3500K
☐ 40 = 4000K

Optic

☐ ZM = 5° - 50° Adjustable Optic

Fitting/Controls (Dimming)

☐ PT2-TE = POWERTrack Fitting & Trailing Edge (10%)
*Consult factory for other mounting options

Voltage

☐ 120 = 120V ☐ 230 = 220-240V ☐ 277 = 277V

Finish

☐ B = Black ☐ W = White ☐ S = Silver

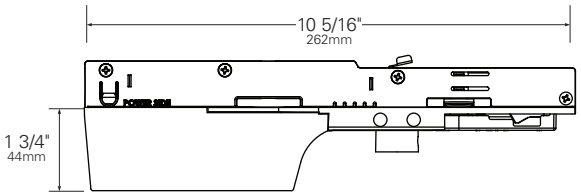
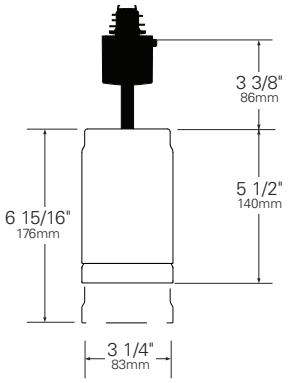
Example Part Number:

LZ-C06	19-80	30	ZM–	PT2-TE	120	W
FIXTURE MODEL	LED RATING	COLOR TEMP	OPTIC	FITTING/ DIMMING	VOLTAGE	FINISH

Other Options (Consult Factory):

- Custom Stems, specify length (4"- 48")
- Custom Finish, RAL palette

LZ MOUNTING OPTIONS

FITTING	SIDE VIEW	STEM LENGTH VIEW
PT2 POWERTrack Fitting		

LZ PERFORMANCE

The performance characteristics of the LZ Zoom family of products can be customized based on the LED module and the optic selected.

Each available LED module is defined by four characteristics – the color rendering index (CRI), the correlated color temperature (CCT), the power that it uses (watts), its "available lumens" and beam spread. Note that available lumens is a theoretical value that represents the light output of the module on its own – no fixture or optic attached.

In the LSI part number, the LED module is specified with a letter and a number that immediately follow the product series number. For example, in the part number LZ-C0619-8030ZM-PT2-TE120W, the **"C0619-8030ZM"** represents an LED module with an output of 1850 lumens, a CRI of 80, a power usage of 20 watts, color temperature of 3000K and a 5° - 50° adjustable degree beam.

Additional parameters, such as Center Beam Candle Power (CBCP), Delivered Lumens, and Efficiency (Lumens per Watt) are all shown in a table that is organized by LED module and optic combination.

CBCP = Center Beam Candle Power

LED Module	Optic (Reflector)		
Lumens/CRI/Wattage	**5°***	**25°***	**50°***
1850/80/20	30,000	4,500	1,500
1500/90/20	24,300	3,600	1,200

Delivered Lumens

LED Module	Optic (Reflector)		
Lumens/CRI/Wattage	**5°***	**25°***	**50°***
1850/80/20	440	660	1,050
1500/90/20	350	530	850

Efficiency = Lumens Per Watt

LED Module	Optic (Reflector)		
Lumens/CRI/Wattage	**5°***	**25°***	**50°***
1850/80/20	22	33	53
1500/90/20	18	27	43

*Preliminary Data

LED Module **Lumens/CRI/Wattage** **SKU Code**	**1850/80/20** **1500/90/20**
Nominal Fixture Power (+/- 20%), Watts	20
Maximum Inrush Current Amps	10
Minimum Power Factor	0.92

Inrush current is instantaneous current drawn by the LED only when fixture is initially powered on or instantaneously changed from full dim to full bright. For more details see Dimming Application Sheet, IS-0119.

LZ PHOTOMETRIC DATA

PHOTOMETRIC DATA

LZ Zoom Series
19-80 LED Rating

Beam Spread (minimum)	**5°**
Center Beam Candlepower	**30000***
CRI	**80**

LZ Zoom Series
19-80 LED Rating

Beam Spread (minimum)	**25°**
Center Beam Candlepower	**4500***
CRI	**80**

LZ Zoom Series
19-80 LED Rating

Beam Spread (minimum)	**50°**
Center Beam Candlepower	**1500***
CRI	**80**

LZ Zoom Series
15-90 LED Rating

Beam Spread (minimum)	**5°**
Center Beam Candlepower	**24300***
CRI	**90**

LZ Zoom Series
15-90 LED Rating

Beam Spread (minimum)	**25°**
Center Beam Candlepower	**3600***
CRI	**90**

LZ Zoom Series
15-90 LED Rating

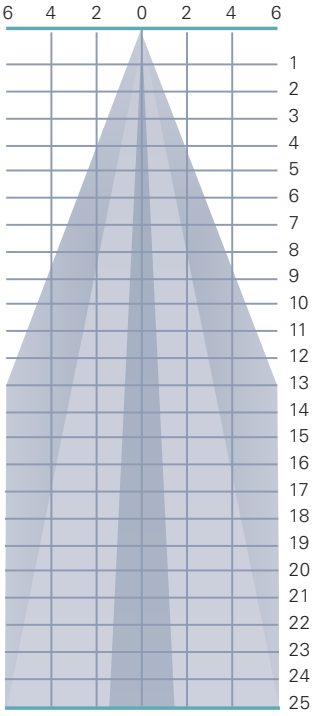
Beam Spread (minimum)	**50°**
Center Beam Candlepower	**1200***
CRI	**90**

*Preliminary Data

LED Rating: 19-80

50°	25°	5°
1500	4500	30000
375	1125	7500
167	500	3333
94	281	1875
60	180	1200
42	125	833
31	92	612
23	70	469
19	56	370
15	45	300
12	37	248
10	31	208
9	27	178
8	23	153
7	20	133
6	18	117
5	16	104
5	14	93
4	12	83
4	11	75
3	10	68
3	9	62
3	9	57
3	8	52
2	7	48

All Distances in Feet

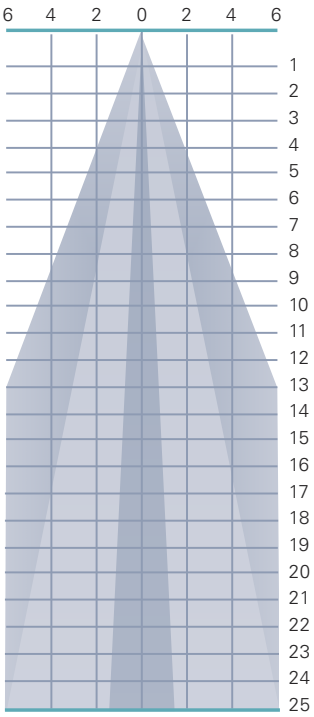


Photometric Data based on LED Rating: 19-80 (1850 Lumens/80CRI/20Watts)

LED Rating: 15-90

50°	25°	5°
1200	3600	24300
300	900	6075
133	400	2700
75	225	1519
48	144	972
33	100	675
24	73	496
19	56	380
15	44	300
12	36	243
10	30	201
8	25	169
7	21	144
6	18	124
5	16	108
5	14	95
4	12	84
4	11	75
3	10	67
3	9	61
3	8	55
2	7	50
2	7	46
2	6	42
2	6	39

All Distances in Feet



Photometric Data based on LED Rating: 15-90 (1500 Lumens/90CRI/20Watts)

LZ ACCESSORIES

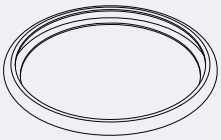
LOUVER HEX ZM

1/8" thick Hexcell black metal louver used for thin profile.

[1]LIGHT BLOCKING SCREENS ZM

Stainless steel mesh screens used alone or in combinations will block from approximately 20% to 90% of the transmitted light without changing color temperature of the light.

No.	% of Light Blocked
ZM801S	20
ZM802S	30
ZM803S	40



BACKER RING ZM

Aluminum ring to hold thin film gels when no other size ZM accessories are being used.

1. Figures vary based upon LED module/optic being used and relationship of screen(s) to LED module/optic and to each other.

LZ GELS

As the foremost innovator in accent lighting, LSI offers a complete range of pre-cut Gels to modify the spread and color of light for the LumeLEX LED Series.

LumeLEX® SPREAD GELS

Size: ZM (71 mm diameter)	Spread Gel
GEL–L1–ZM	1° Spread Gel
GEL–L5–ZM	5° Spread Gel
GEL–L10–ZM	10° Spread Gel
GEL–L20–ZM	20° Spread Gel
GEL–L30–ZM	30° Spread Gel
GEL–L40–ZM	40° Spread Gel
GEL–L60–ZM	60° Spread Gel
GEL–L80–ZM	80° Spread Gel
GEL–L30B5–ZM	30° by 5° Spread Gel
GEL–L40B2–ZM	40° by 0.2° Spread Gel
GEL–L60B1–ZM	60° by 1° Spread Gel
GEL–L60B10–ZM	60° by 10° Spread Gel
GEL–L75B45–ZM	75° by 45° Spread Gel
GEL–L90B60–ZM	90° by 60° Spread Gel
GEL–R101–ZM	Beam Softener

LumeLEX® COLOR GELS

Size: ZM (71 mm diameter)	Gel Color	% of Light Transmission	Size: ZM (71 mm diameter)	Gel Color	% of Light Transmission
GEL–R2–ZM	Bastard Amber	78	GEL–R312–ZM	Canary	85
GEL–R7–ZM	Pale Yellow	96	GEL–R3204–ZM	Half Blue	52
GEL–R12–ZM	Straw	88	GEL–R331–ZM	Shell Pink	68
GEL–R13–ZM	Straw Tint	78	GEL–R383–ZM	Sapphire Blue	4
GEL–R14–ZM	Medium Straw	68	GEL–R397–ZM	Pale Grey	70
GEL–R21–ZM	Golden Amber	43	GEL–R2001–ZM	Storaro Red	12
GEL–R25–ZM	Orange Red	14	GEL–R2004–ZM	Storaro Green	15
GEL–R26–ZM	Light Red	12	GEL–R2009–ZM	Storaro Violet	3
GEL–R27–ZM	Medium Red	4	GEL–R3202–ZM	Full Blue	36
GEL–R57–ZM	Lavender	24	GEL–R3206–ZM	Third Blue	64
GEL–R62–ZM	Booster Blue	54	GEL–R3216–ZM	Eighth Blue (Boosts 3200K to 3300K)	81
GEL–R71–ZM	Sea Blue	30	GEL–R3318–ZM	Tough 1/8 Minusgreen	89
GEL–R72–ZM	Azure Blue	44	GEL–R3410–ZM	Roscosun (1/8 CTO) (Reduces 5500K to 4900K)	92
GEL–R91–ZM	Primary Green	7	GEL–R3441–ZM	Full Straw (CTS)	50
GEL–R97–ZM	Light Grey	50	GEL–R3443–ZM	Quarter Straw (CTS)	81
GEL–R98–ZM	Medium Grey	25	GEL–R4330–ZM	CalColor 30 Cyan	63
GEL–R101–ZM	Light Frost	N/A	GEL–R4415–ZM	CalColor 15 Green	67
GEL–R104–ZM	Tough Silk	N/A	GEL–R4490–ZM	CalColor 90 Green	25
GEL–R119–ZM	Lt. Hamburg Frost	N/A	GEL–R4860–ZM	CalColor 60 Pink	46
GEL–R121–ZM	Blue Diffusion	N/A	GEL–R4890–ZM	CalColor 90 Pink	38
GEL–R305–ZM	Rose Gold	75	GEL–R4930–ZM	CalColor 30 Lavender	47

* Backer Ring ZM required to hold gels when no other rimmed "ZM" accesories are used.

LSI ROSCO GEL CCT CONVERSION CHART FROM 3000K

Type	ROSCO #	ROSCO Description	Resulting CCT
Amber Filters Lower CCT	3420	Double CTO	1531
	3407	Sun CTO	1999
	3401	Sun 85	2154
	3411	Sun 3/4 CTO	2154
	3408	Sun 1/2 CTO	2414
	3409	Sun 1/4 CTO	2664
	3410	Sun 1/8 CTO	2830
	3114	UV Filter	2930
Blue Filters Raise CCT	3220	Double Blue	N/A
	3202	Full Blue	4942
	3203	Three-Quarter Blue	4286
	3204	Half Blue	3769
	3206	Third Blue	3517
	3208	Quarter Blue	3297
	3216	Eighth Blue	3112

COLOR MEDIA

COLOR FILTERS

As the foremost innovator in accent lighting, LSI offers a complete range of permanent fade-free glass color filters, which are available in nine stock diameters. All glass color filters are rimmed in a seamless aluminum ring and are slotted for heat expansion.

Size	Diameter	LSI Fixture Series
AAA	2 3/8″	LumeLEX® 2020/2030/2031/2038, SSLCX16, SSL260, LumeLEX MAR-S
ZM	2 13/16″	LZ Zoom
AA	3″	LumeLEX® 2024 (with LX2024-Holder or LX2024-Barndoor), LumeLEX® 2044, LumeLEX 2048
A	3 1/2″	LumeLEX® 2060, SSL230, SSLCX30, SSLGR30CL, SSLGR36
B	4 1/4″	LumeLEX® MAR-L
C	4 3/4″	LumeLEX® 2084, LumeLEX® 2088, SSL238, SSLCX36, SSLCX38, SSLGR38CL

No.	Color	[1]% of Light Transmission
902	Medium Pink	36
903	Deep Pink	37
904	Flesh Pink	73
906	Pale Lavender	14
907	Surprise Pink	19
908	Lilac	21
910	Warm Red	10
911	Strawberry	6
912	Ruby	4
913	Magenta	1
914	Light Amethyst	25
915	Medium Amethyst	16
916	Deep Amethyst	4
917	Olive	18
918	Light Green	68
920	Medium Green	25
921	Deep Green	7
922	Silver green	65
923	Yellow Green	49
924	Emerald Green	12
925	Light Turquoise	68
926	Medium Turquoise	40
927	Deep Turquoise	17
928	Light Blue	34
930	Medium Blue	3
932	Daylight	59
933	Gene Moore Blue	18
936	Grey	56
937	Light Blue Green	17
939	Light Amber	68
940	Medium Amber	48
941	Deep Amber	43
942	Straw	78
943	Gold	87
944	Canary Yellow	84
945	Lemon	81
946	Pumpkin	32
947	Tangerine	20
948	Orange	23
949	Pink Gold	54
950	Bronze	48
951	Brass	11
952	Autumn Tan	11
953	Leaf Brown	19
954	Butter Pecan	3
955	Toasted Almond	1

Notes:

1. Values given are approximate due to slight variations in glass color and thickness.

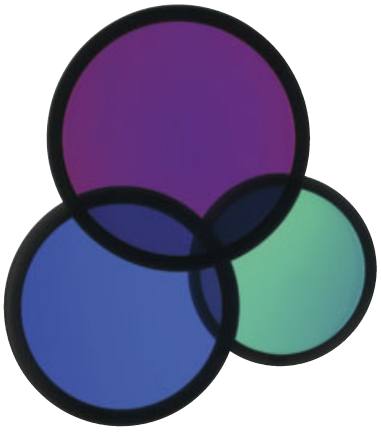
COLOR MEDIA

DICHROIC COLOR FILTERS

In addition to our complete line of glass color filters, LSI now offers dichroic glass color filters that achieve purer, more saturated, richer color by selective wavelength transmission. Since these filters reflect rather than absorb the unwanted color wavelengths, a higher intensity of colored light can be obtained with fewer or lower wattage fixtures. In addition, this selective transmission allows for very accurate color matching from filter to filter.

All standard LSI filter sizes are available in a wide palette of well chosen dichroic colors that can be used with all LSI fixtures that accept accessories.

LSI dichroic glass color filters have the added benefit of being rimmed for extra durability to allow for frequent usage without fear of breakage or edge chipping.



Size	Diameter	LSI Fixture Series
AAA	2 3/8"	LumeLEX® 2020/2030/2031/2038, SSLCX16, SSL260, LumeLEX MAR-S
ZM	2 13/16"	LZ Zoom
AA	3"	LumeLEX® 2024 (with LX2024-Holder or LX2024-Barndoor), LumeLEX® 2044, LumeLEX 2048
A	3 1/2"	LumeLEX® 2060, SSL230, SSLCX30, SSLGR30CL, SSLGR36
B	4 1/4"	LumeLEX® MAR-L
C	4 3/4"	LumeLEX® 2084, LumeLEX® 2088, SSL238, SSLCX36, SSLCX38, SSLGR38CL

Technical Data

Dichroic color filters are created in a vacuum chamber by multi-layer vapor deposits of different minerals onto low expansion, chemically resistant Borosilicate glass.

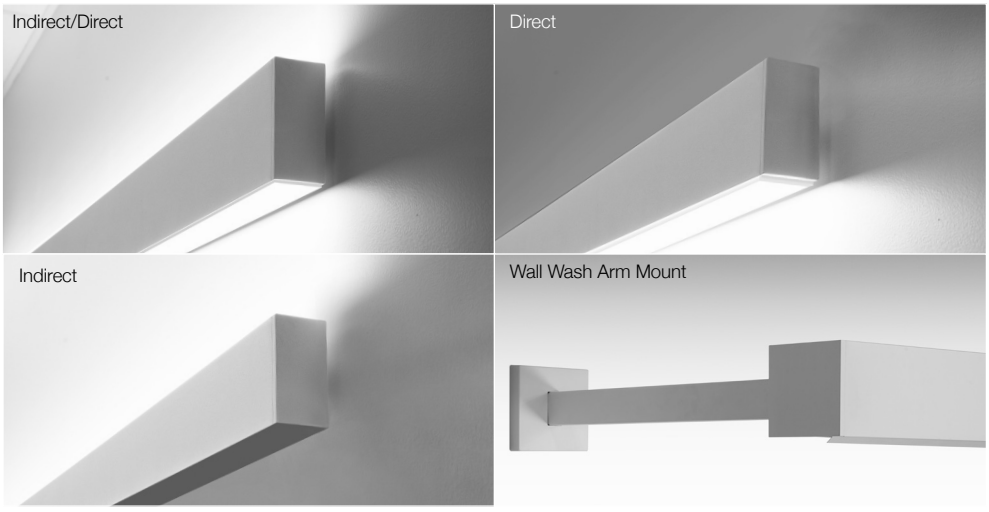
Deposits are made in alternating layers of varying microscopic thickness which allow very narrow color wavelengths to be selectively transmitted and all other wavelengths to be reflected.

LSI does not recommend using dichroic color filters with lamps or fixtures that have beam spreads greater than 40° because a secondary color aura is created by the wide angular transmitted wavelengths that are different than the desired color wavelength.

Since there is mainly transmission and reflection of the color wavelengths by the dichroic filter and very little absorption, the dichroic filter can be used with many high temperature lights that normally would not accept color filters.

No.	Color	% of Light Transmission
2001	Light Pink	69
2002	Medium Pink	43
2003	Hot Pink	11
2004	Pale Pink	55
2010	Deep Magenta	29
2011	Lavender	24
2012	Vivid Magenta	31
2013	Lavender Accent	48
2014	Lilac	37
2015	Purple Fusion	12
2020	Sky Blue	39
2021	Sea Blue	39
2022	Cyan	33
2023	Light Blue Green	30
2024	Primary Blue	24
2025	Medium Red Blue	15
2026	Deep Purple	16
2027	Peacock Blue	53
2028	Mediterranean Blue	20
2029	Boost Blue	51
2040	Light Yellow Green	64
2041	Fern Green	47
2042	Turquoise	35
2043	Primary Green	31
2044	Industrial Green	64
2050	Yellow	80
2051	Amber	71
2052	Amber Blush	38
2053	Bastard Amber	71
2054	Goldenrod	63
2055	Bright Straw	56
2060	Medium Orange	51
2061	Orange	44
2070	Flame Red	27
2071	Primary Red	25

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount



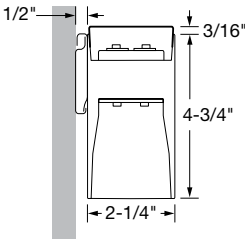
High Performance 2" Aperture is a patented, linear LED luminaire family. HP-2 delivers excellent performance using an advanced optical design and mid-power LEDs. Achieving 90% of initial light output at 100,000+ hours and backed by a 10-year performance-based warranty on all standard components.

Signal White is standard finish

Note: see page 6 for all aesthetic options

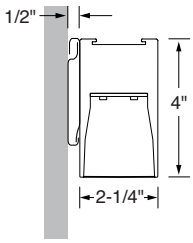
CROSS SECTIONS

Indirect/Direct
Top Glow Diffuser (standard)



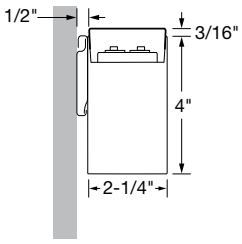
Flush Downlight Diffuser (standard)

Direct

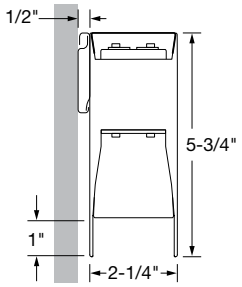


Flush Downlight Diffuser (standard)

Indirect
Top Glow Diffuser (standard)

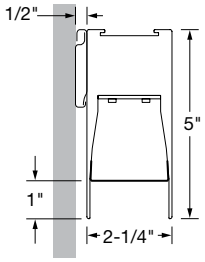


Indirect/Direct Regressed
Top Glow Diffuser (standard)



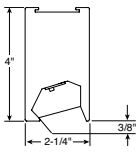
Flat Diffuser with 1" Regress (standard)

Direct Regressed

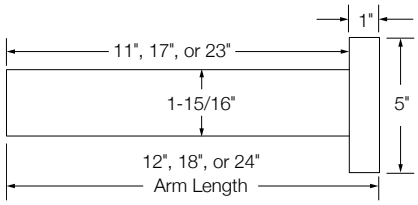


Flush Downlight Diffuser (standard)

Wall Wash Arm Mount



Kicker (standard)



ALSO AVAILABLE IN

Pendant (**D, ID, I**)

Recessed (**R**)

Surface Mount (**SM**)

Option Available

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

BODY TYPE

Platform	Series Name	Luminaire Type	Luminaire Distribution	Total Length of Run
HP - High Performance	**2**	**WM** - Wall Mount [1] **WM RG** - Wall Mount Regressed [1] **AM** - Arm Mount	**D** - Direct **WW-D** - Wall Wash Direct **ID** - Indirect/Direct **I** - Indirect	_____ Minimum 2' section length. Increments accurate to 1/16" (±1/32"), standard. 12' maximum section length.

OUTPUT AND LED TYPE

Uplight Output ID & I Only
S - Standard **B** - Boosted Standard **H** - High **V** - Very High **TL** - Tailored:_____lm/ft* * Specify lm/ft of outputs between Standard (S) and Very High (V). Consult factory for tailored lumen output outside of this range.

OUTPUT AND LED TYPE

Downlight Output ID & D Only	LED CRI/CCT
S - Standard **B** - Boosted Standard **H** - High **V** - Very High **TL** - Tailored:_____lm/ft* * Specify lm/ft of outputs between Standard (S) and Very High (V). Consult factory for tailored lumen output outside of these range.	**830** - 80 CRI, 3000K **835** - 80 CRI, 3500K **840** - 80 CRI, 4000K **930** - 90 CRI, 3000K **935** - 90 CRI, 3500K **940** - 90 CRI, 4000K **8TW** - 80 CRI, Tunable White **9TW** - 90 CRI, Tunable White

MECHANICAL/OPTICAL OPTIONS

Uplight	Downlight	Reflector System
TG - Top Glow (standard) **F** - Flush **ASY-L** - Asymmetric Left Optic **ASY-R** - Asymmetric Right Optic **ASYTG-L** - Asymmetric Left Optic with Top Glow **ASYTG-R** - Asymmetric Right Optic with Top Glow	**F** - Flush (standard) [1] **BG** - Bottom Glow [1] **DL** - 1" Drop Down Lens **RG-D** - Flat Diffuser with 1" Regress [1, 2] **RG-WCB** - White Cross Blade Baffle [1, 2] **RG-LHE** - Hollowed Ellipse Louver [1, 2] **RG-LHC** - Hex Louver [1, 2] **K** - Kicker for Wall Wash only (standard) **FO** - Fully Open for Wall Wash only	**96LG** - 96 Low Gloss White **SSA** - Semi-Specular Aluminum for Wall Wash only

ELECTRICAL OPTIONS

Voltage	Circuiting [3]	Driver Selection
120 - 120 Voltage **277** - 277 Voltage **347** - 347 Voltage	**SC** - Single Circuit* One single circuit in a run **DC** - Dual Circuit* [4] Independent control of up and down separately in an I/D style fixture **MC** - Multi-Circuit* More than one switch leg or zone. Factory shop drawings required * Battery, Night Light, and Emergency to Generator circuits are in addition to the normal luminaire circuit(s)	**0-10V Driver Options** **FC-10%** - 0-10V 10% [5] (standard) **FC-1%** - 0-10V 1% [5] **OSR-10%** - Osram OTi, 0-10V 10% [5] **OSR-1%** - Osram OTi, 0-10V 1% [5] **ELD-10V-0%** - EldoLED SOLOdrive, 0-10V 0.1% **OSR-10V-TW** - Osram OTi, 0-10V 10% *(Tunable White)* [5] **DALI Driver Options** **FC-DALI-1%** - DALI 1% **OSR-DALI-1%** - Osram Dexal, 1% **ELD-DALI-0%** - EldoLED SOLOdrive, 0.1% **ELD-DALI-TW** - EldoLED DUALdrive LightShape, 1% *(Tunable White)* **DMX Driver Options** **FIN-DMX** - Finelite DMX 1% *(Tunable White - FineTune Controls Only)* [6] **ELD-DMX** - EldoLED POWERdrive, 0.1% **ELD-DMX-TW** - EldoLED POWERdrive, 0.1% *(Tunable White)* **Lutron Driver Options** **LUT-ES1** - Lutron, Ecosystem 1% **LUT-ES5** - Lutron, Ecosystem 5% **LUT-2W** - Lutron, 2-wire (120V only) 1% **LUT-TW** - Lutron T-Series, EcoSystem 1% *(Tunable White)* See Page 3 for additional driver options and details

MOUNTING OPTIONS

Mounting Method	Endcap Style	Finish
MB - Mounting Bracket [7] **AM12** - 12" [8] **AM18** - 18" [8] **AM24** - 24" [8]	**FE** - Flat Endcap (standard) **DE** - 1" Drop Endcap [9] **OE** - Open Endcap [10]	**SW** - Signal White (standard) **FB** - Finelite Black [11] **SA** - Satin Aluminum [11] **####** - RAL Color Code [11] _____

OTHER OPTIONS

Emergency Style (Optional)	Integrated Sensor (Optional)
FAC CHO - Factory Choice Battery Back-up **EM/GEN** - Emergency to Generator **NL** - Night Light **BSL310LP** - Bodine Battery Back up Low Profile **GTD** - Generator Transfer Device	**OBO** - Occupancy [1] **OBD** - Daylight [1] **OBE** - Enlighted [1, 12, 13]

[1] Not available for Wall Wash
[2] Regressed only
[3] Contact factory for switching options
[4] Indirect/Direct only
[5] Add DTO to gain "Dim to Off" functionality (FC-10% - DTO)
[6] B & V outputs only
[7] Wall Mount only
[8] Arm Mount only
[9] 1" Drop Down Lens downlight only
[10] Available with Hollowed Ellipse Louver (**LHE**) only
[11] 20 business days lead time for color
[12] Enlighted for Wall Wash fixtures. Enlighted Control Unit & Sensor Cable installed for Remote mounting sensor
[13] Enlighted components installed by Finelite, provided by others

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

SPECIFICATIONS

BODY TYPE

CONSTRUCTION: Precision-cut 6061-T6 extruded aluminum body. Internal joiner system and plug-together wiring are standard.

LENGTHS: Any length, 2' minimum, in increments down to 1/16th" (±1/32"). 12' maximum section length. Hollowed Ellipse Louver (**LHE**), Hex Louver (**LHC**), and White Cross Blade Baffle (**WCB**) are available in 1' increments.

MITERED CORNERS[1]: Illuminated corners of greater than 60° and less than 180° in a single plane, available with Flush Diffuser, Bottom Glow Diffuser, 1" Drop Down Lens[2], Regressed Diffuser, or White Cross Blade Baffle[3]. Corners not available with Wall Wash (**WW-D**), Hollowed Ellipse Louver (**LHE**) or Hex Louver (**LHC**). Consult factory for tailored lighting options.

OUTPUT AND LED TYPE

LIGHT OUTPUT: Four lumen packages available, Standard (**S**), Boosted Standard (**B**), High (**H**), and Very High (**V**). For lengths 3' and greater, the uplight and downlight can be specified with different lumen packages and dual controls. For Tailored Outputs outside of range from Standard (**S**) to Very High (**V**), consult factory. Light engines are replaceable.

MECHANICAL/OPTICAL OPTIONS

UPLIGHT OPTION[4]: Patented Top Glow frost white diffuser standard. 12' maximum diffuser length. 73% transmissive, 99% diffusion. Internal secondary diffusers at corners ensure visually seamless, uniform, continuous illumination Optional: Flush frost white snap-in diffuser, 73% transmissive, 99% diffusion; **ASY-L** distributes light to the left, **ASY-R** distributed light to the right of the luminaire. Consult factory for more tailored lumen outputs.

DOWNLIGHT OPTION[5]: 12' maximum diffuser length. Flush frost white snap-in diffuser standard, 73% transmissive, 99% diffusion. Internal secondary diffusers at corners ensure visually seamless, uniform, continuous illumination. Available with Flush (**F**), Bottom Glow (**BG**), 1" Drop Down Lens (**DL**), White Cross Blade Baffle (**WCB**)[6], Hollowed Ellipse Louver (**LHE**)[6], Hex Louver (**LHC**)[6], and Regressed downlight diffusers (**RG**). 1" Drop Down Lens made of highly efficient acrylic. Available with a solid endcap or an endcap with a diffuse filler to continue the luminous aesthetic. Consult factory for more tailored lumen outputs.

LUMEN MAINTENANCE: 90% of initial light output (L90) at 100,000+ hours; 70% of initial light output (L70) at 200,000+ hours.

REFLECTORS: Wall Mount: Die-formed 20-gauge cold-rolled steel reflectors finished in 96LG High Reflectance white power coat paint. **Arm Mount**: The standard Semi-Specular Aluminum (**SSA**) Kicker (**K**) reflector delivers light high on the vertical surface. The Kicker reflector can be easily removed for open distribution (**FO**).

ELECTRICAL FEATURES

STATIC WHITE FEED: Standard with one 18-gauge/5-conductor single-circuit feed controlling uplight and downlight together (power and dimming). Specify dual feeds for independent control of uplight and downlight. 14-gauge feed used when luminaire current exceeds 5 amps.

TUNABLE WHITE FEED: Standard with one 18-gauge/5-conductor single-circuit feed. 14-gauge feed used when luminaire current exceeds 5 amps. DMX and power feed at same location (standard). DMX feeds cannot be cut or spliced. DMX feeds should be ordered based on fixed lengths.

STATIC WHITE DRIVER: Replaceable 120V, 277V, and 347V Constant Current Reduction dimming driver standard. Can be wired dimming or non-dimming. 0-10V dimming controls with a range of 10%- 100% standard. Dimming to 1% available. Separate dimming for uplight and downlight available. Driver is fully accessible from below the ceiling.

- **Power Factor:** ≥ 0.9
- **Total Harmonic Distortion (THD):** <20%
- **Expected driver lifetime:** 100,000 hours

LUTRON DRIVER OPTIONS:

- **LUTES1** (Hi-lume 1% EcoSystem with Soft-On, Fade-to-Black dimming (LDE1 series))
- **LUTES5** (5-Series 5% EcoSystem (LDE5 Series)),
- **LUT2W** (Hi-lume 1% 2-wire, 120V forward phase dimming (LTEA series)).

TUNABLE WHITE DRIVER: Replaceable LED driver. Driver is accessible from below the ceiling. 120V, 277V, and 347V.

- **Power factor:** ≥0.90
- **Total Harmonic Distortion (THD):** <20%
- **Dimming Range:** 100%-10%
- **Expected driver lifetime.:** 100,000 hours
- FineTune DMX is 1%

[1] Not available with Wall Wash
[2] Indirect/Direct and Direct only
[3] White Cross Blade (WCB) baffles not available with custom angles. Available in 90 degrees only
[4] Wall Mount Indirect/Direct, Wall Mount Regressed Indirect/Direct, and Wall Mount Indirect only
[5] Wall Mount Indirect/Direct, Wall Mount Regressed Indirect/Direct, Wall Mount Direct, and Wall Mount Regressed Direct only
[6] Wall Mount Regressed Indirect/Direct & Wall Mount Regressed Direct only

Continued

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

SPECIFICATIONS

LUTRON TUNABLE WHITE DRIVER OPTION: LUT-TW (1% T-Series 2-Channel Digital Tunable White (PSQ Series)).

MOUNTING OPTIONS

HANGING HARDWARE: Wall Mount: Luminaire hangs securely from mounting brackets fastened directly to the wall for easy installation. Luminaire stands 1/2" off the wall. The mounting bracket is concealed behind the luminaire. **Arm Mount**: bracket mounts directly to wall j-box, extends luminaire 12", 18", or 24" from wall. Other lengths available. Consult factory.

TUNABLE WHITE DMX HANGING HARDWARE: For grid ceiling applications the dual GridBox™ mounting is supplied (standard). For hard ceiling applications the ceiling mounting box is supplied (standard). DMX feeds cannot be cut or spliced. DMX feeds should be ordered based on fixed lengths. Available DMX pendant feed lengths are 5' (standard), 12', and 30'.

TUNABLE WHITE DMX INTERCONNECTION CABLES: Luminaires are pre-wired with plug-and-play interconnection cables to support easy plug-together joining of luminaire runs. If a non-FineTune DMX system has been specified, a DMX to RJ45 converter is provided.

OTHER OPTIONS

ENDCAPS: Flat diecast aluminum endcaps (**FE**) add 1/4" to each end of luminaire. 1" Drop Down Lens Endcap (**DE**)[7] includes diffuse element to continue luminance of drop lens. Open Endcap (**OE**) is for use with the Hollowed Ellipse Louver (**LHE**); following the curve of the louver.

EMERGENCY STYLE: Optional emergency to generator/inverter wiring, internal generator transfer switch, nightlight wiring, step-dimming driver, backup battery. Factory choice low-profile backup battery available.

- **Indirect/Direct:** backup batteries deliver 1608 lumens. 12' minimum luminaire length. 2' illuminated (downlight standard).
- **Direct:** backup batteries deliver 1608 lumens. 8' minimum luminaire length. 2' illuminated.
- **Indirect:** backup batteries deliver 1874 lumens. 8' minimum luminaire length. 2' illuminated.
- **Wall Wash:** backup batteries deliver 1500 lumens. 8' minimum luminaire length. 2' illuminated.

TUNABLE WHITE ELECTRICAL OPTIONS[8]:

- **TW Driver Options 0-10V:** EM/GEN, GTD or Battery Back up
- **FineTune DMX:** EM/GEN or Battery Back up
- **DMX:** Battery Back up
- **DALI:** EM/GEN, GTD or Battery Back up
- **LUTRON:** EM/GEN, GTD or Battery Back up

INTEGRATED SENSORS: Integrated PIR (Passive Infrared) occupancy or daylight sensors available with Flush and Bottom Glow downlight diffusers. Refer to Occupancy Sensor, Daylight Sensor, and Enlighted Sensor tech sheets for more info.

FINISHES: Finelite Signal White (**SW**) powder coat, Finelite Black (RAL 9005) with semi gloss fine texture (**FB**)[9], and Satin Aluminum (**SA**)[9] are standard. Optional Adder: 185 RAL colors[9] are available.

LABELS: Luminaire and electrical components are ETL-listed conforming to UL 1598 in the U.S.A. and CAN/CSA C22.2 No. 250.0 in Canada. In accordance with NEC Code 410.130 (G), this luminaire contains an internal driver disconnect. UL 924 and UL 2108 - PoE options available on request. These fixtures are rated for Damp Location. Finelite products use electronic components that are RoHS compliant, and the mechanical components of the luminaire have been verified to not knowingly contain any restricted substances listed per RoHS Directive 2015/863. Consult factory for tailored lighting options.

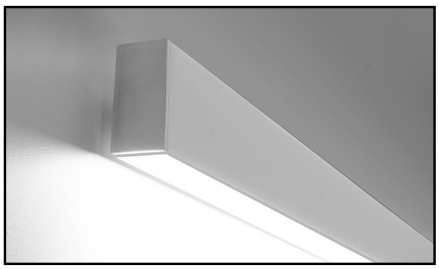
WEIGHT[10]: ID - 2.9 lb/ft; D - 2.3 lb/ft; I - 2.3 lb/ft; AM - 2.9 lb/ft (luminaire only)

WARRANTY: 10-year performance-based warranty on all standard components. Optional accessories such as emergency battery packs are covered by their individual manufacturer warranties.

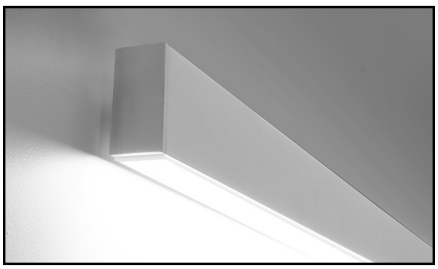
[7] Available in Indirect/Direct Regressed & Direct Regressed only
[8] Consult Finelite for Generator Transfer Device and Battery Back up fit
[9] 20 business days lead time for color
[10] Excludes Battery Back up and Generator Transfer Device weight

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

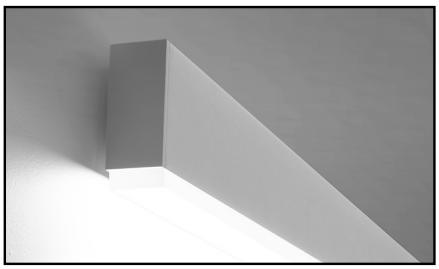
AESTHETIC OPTIONS



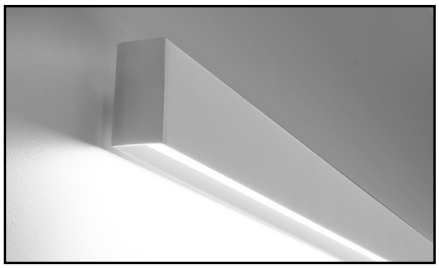
Flush Diffuser (**F**)



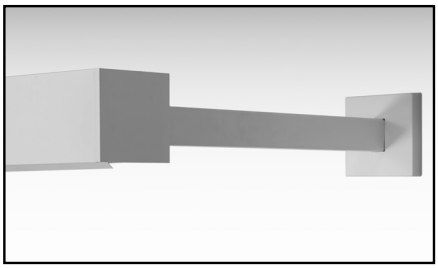
Bottom Glow Diffuser (**BG**)



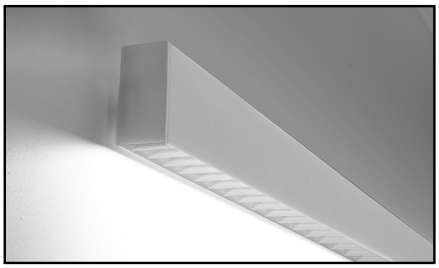
1" Drop Down Lens (**DL**)



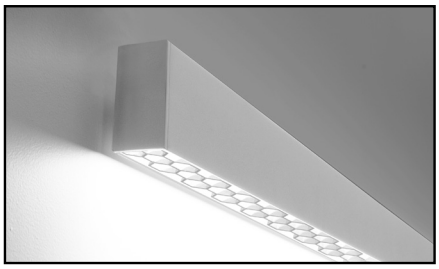
Flat Diffuser with 1" Regressed (**RG-D**)



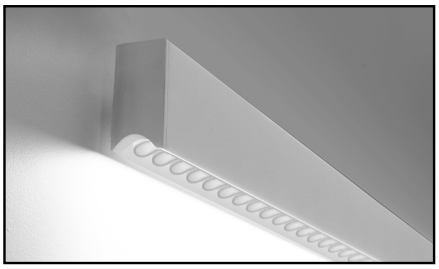
Kicker (**K**) - Wall Wash Arm Mount only



White Cross Blade Baffle[1] (**RG-WCB**)



Hex Louver[1] (**RG-LHC**)

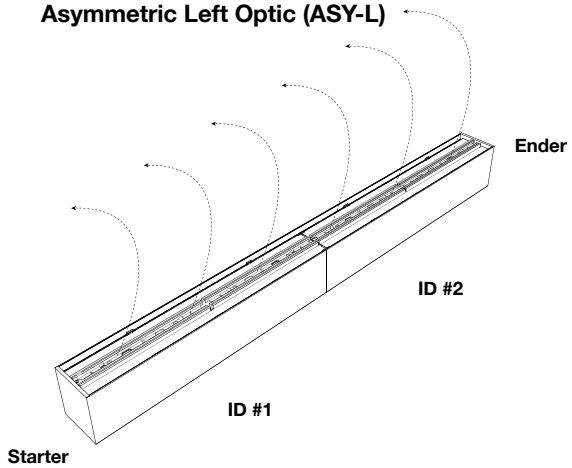


Hollowed Ellipse Louver[1] (**RG-LHE**)

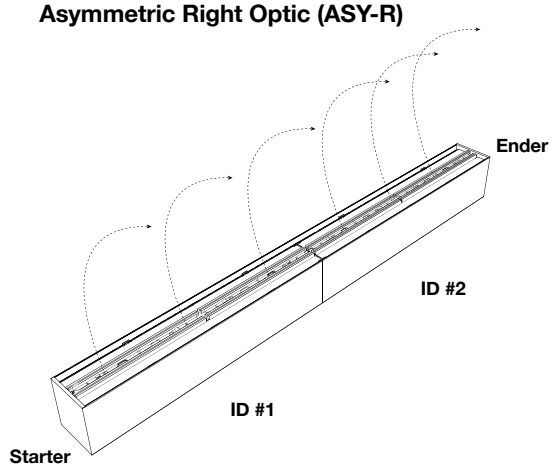
ASYMMETRIC OPTIONS

Use this tool to understand how to specify Asymmetric for your project. The diagrams below show a linear run from power feed to ender. Specify, ASY-L distributes light to the left or ASY-R distributed light to the right.

Asymmetric Left Optic (ASY-L)



Asymmetric Right Optic (ASY-R)

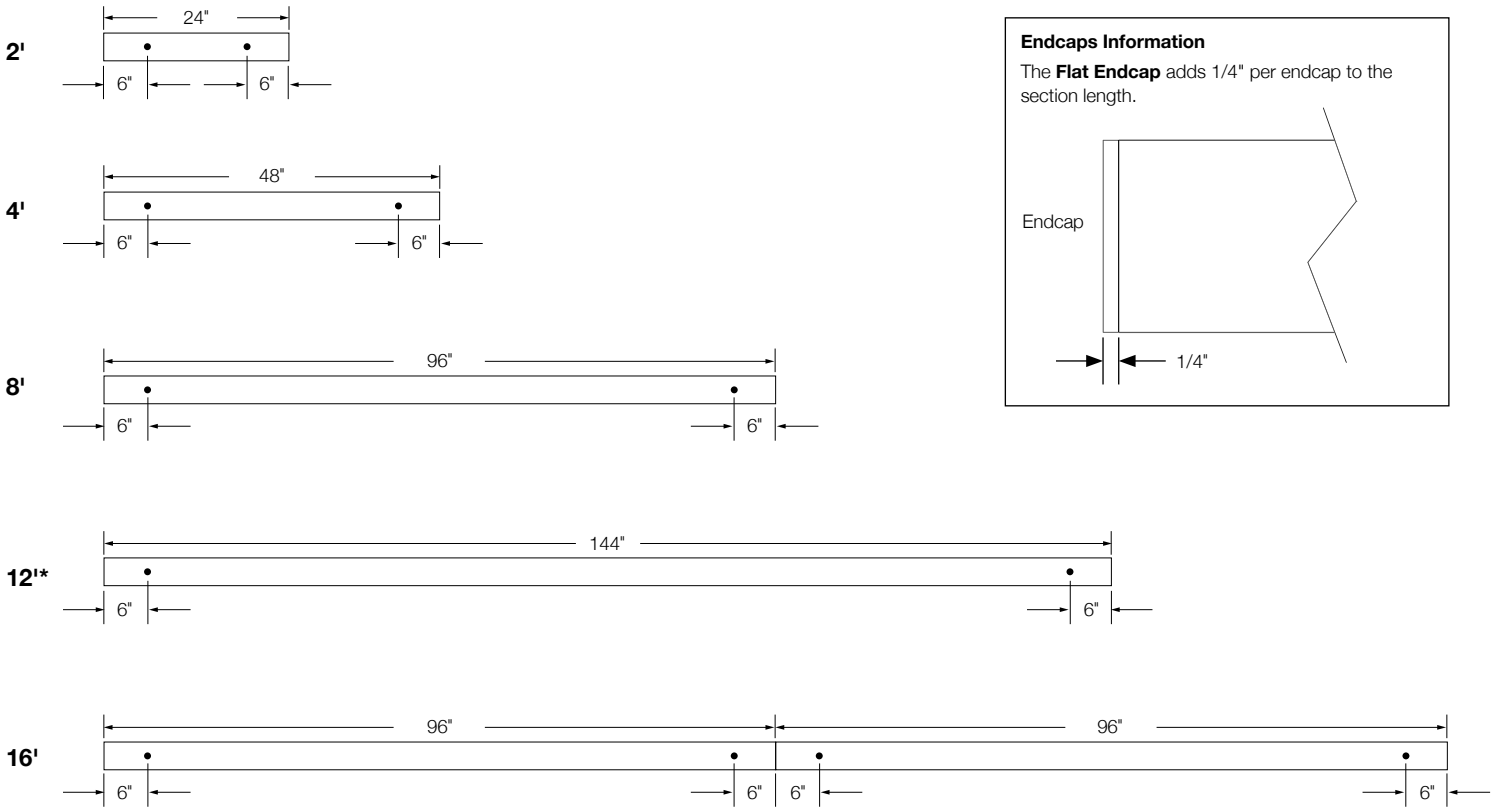


[1] Regressed only

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

WALL WASH ARM MOUNT - Run Lengths & Mounting Location Examples

Tailored Lengths Available Down To 1/16" (±1/32")



Endcaps Information

The **Flat Endcap** adds 1/4" per endcap to the section length.

• = Bracket Location

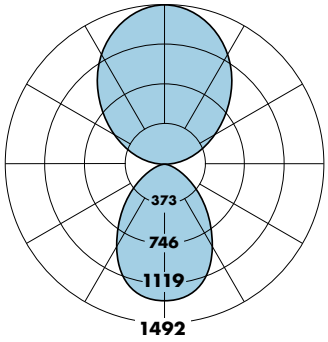
* = 12' Maximum spacing for two Arm Mount supports

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Indirect/Direct Photometry - 4' Luminaire 3500K

HP2-WM-ID-4'-V-V-835
Uplight: Flush Diffuser / **Downlight:** Flush Diffuser

Distribution: 55% Up (**V**) / 45% Down (**V**)
Efficacy: 95 lm/W
Uplight: 3813 lumens (953 lumens/foot)
Downlight: 3175 lumens (794 lumens/foot)
Total luminaire output: 6988 lumens (1747 lm/ft)
73.8 watts (18.5 W/ft)
Peak Candela Value: 1492 @ 180°
CRI: 80 / CCT: 3500K
ITL LM79 Report 85132



CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	FLUX
0	1314	1314	1314	1314	1314	
5	1306	1307	1305	1304	1304	124
15	1241	1233	1231	1225	1220	346
25	1114	1098	1089	1076	1064	501
35	942	925	910	887	877	568
45	749	734	718	693	683	552
55	553	542	526	506	499	470
65	368	360	349	337	332	346
75	203	198	192	187	184	204
85	60	59	58	57	55	64
90	0	0	0	0	0	
95	71	68	68	69	70	77
105	244	241	236	235	234	252
115	442	439	437	427	425	431
125	661	649	653	643	638	581
135	884	871	875	866	866	673
145	1099	1084	1088	1084	1077	679
155	1283	1268	1275	1269	1263	585
165	1415	1405	1408	1406	1403	396
175	1482	1482	1482	1482	1481	141
180	1492	1492	1492	1492	1492	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire				
	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	2861 [↑55% I 45%↓]	3262 [↑60% I 40%↓]	4265 [↑70% I 30%↓]	5113 [↑75% I 25%↓]
↓B [1]	3195 [↑49% I 51%↓]	3596 [↑55% I 45%↓]	4600 [↑65% I 35%↓]	5447 [↑70% I 30%↓]
↓H [1]	4030 [↑39% I 61%↓]	4432 [↑44% I 56%↓]	5435 [↑55% I 45%↓]	6282 [↑61% I 39%↓]
↓V [2]	4736 [↑33% I 67%↓]	5137 [↑38% I 62%↓]	6141 [↑48% I 52%↓]	6988 [↑55% I 45%↓]

Light Output, 3500K, 80 CRI (Lumens Per Foot)				
	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	715	815	1066	1278
↓B [1]	799	899	1150	1362
↓H [1]	1008	1108	1359	1571
↓V [2]	1184	1284	1535	1747

Power, 3500K (Watts Per Foot)				
	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	7.2	8.2	10.7	12.8
↓B [1]	8.2	9.2	11.7	13.8
↓H [1]	10.7	11.7	14.2	16.3
↓V [2]	12.8	13.8	16.3	18.5

Efficacy, 3500K, 80 CRI (Lumens Per Watt)				
	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	99	99	100	100
↓B [1]	97	98	99	99
↓H [1]	94	95	96	96
↓V [2]	92	93	94	95

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**) / Standard Output (**S**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 4265 lm x 0.789 = 3365 lm

Total Light Output per Foot: 1066 lm/ft x 0.789 = 841 lm/ft.

watts/foot: 10.7 W/ft.

$$\textbf{Efficacy} = \frac{841\ \frac{\text{lm}}{\text{ft.}}}{10.7\ \frac{\text{W}}{\text{ft.}}} = 79\ \text{lm/W}$$

S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

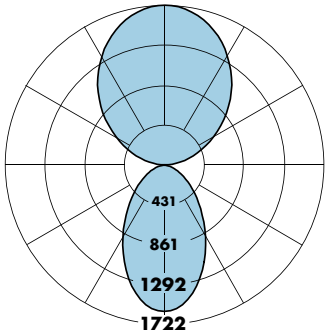
[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 85132

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Indirect/Direct Photometry - 4' Luminaire 3500K

HP2- WM RG-ID-V-V-835-F
Uplight: Flush Diffuser / **Downlight:** Regressed Diffuser

Distribution: 59% Up (**V**) / 41% Down (**V**)
Efficacy: 99 lm/W
Uplight: 4304 lumens (1076 lumens/foot)
Downlight: 2928 lumens (732 lumens/foot)
Total luminaire output: 7232 lumens (1808 lm/ft)
73.2 watts (18.3 W/ft)
Peak Candela Value: 1722 @ 180º
CRI: 80 / CCT: 3500K
ITL LM79 Report 90352



CANDELA DISTRIBUTION

	0.0	22.5	45	67.5	90	Flux
0	1585	1585	1585	1585	1585	
5	1573	1571	1564	1558	1556	147
15	1492	1459	1411	1364	1342	396
25	1334	1260	1157	1068	1034	536
35	1118	1013	875	770	730	560
45	872	758	613	516	483	495
55	631	517	391	324	303	381
65	403	307	218	178	173	248
75	206	138	103	96	94	130
85	48	30	26	25	24	34
90	0	0	0	0	0	
95	69	69	69	66	64	76
105	251	250	250	249	247	265
115	478	474	476	471	470	470
125	734	726	728	723	721	650
135	1000	990	994	990	982	765
145	1265	1245	1253	1248	1238	781
155	1482	1463	1476	1467	1460	676
165	1635	1623	1630	1626	1621	458
175	1712	1711	1711	1710	1709	162
180	1722	1722	1722	1722	1722	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	2960 (↑60% I 40%↓)	3414 (↑65% I 35%↓)	4546 (↑74% I 26%↓)	5503 (↑78% I 22%↓)
↓B [1]	3269 (↑54% I 46%↓)	3722 (↑60% I 40%↓)	4854 (↑69% I 31%↓)	5811 (↑74% I 26%↓)
↓H [1]	4039 (↑44% I 56%↓)	4492 (↑49% I 51%↓)	5625 (↑60% I 40%↓)	6581 (↑65% I 35%↓)
↓V [2]	4690 (↑38% I 62%↓)	5143 (↑43% I 57%↓)	6276 (↑53% I 47%↓)	7232 (↑59% I 41%↓)

Light Output, 3500K, 80 CRI (Lumens Per Foot)

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	740	853	1137	1376
↓B [1]	817	930	1214	1453
↓H [1]	1123	1406	1645	1645
↓V [2]	1172	1286	1569	1808

Power, 3500K (Watts Per Foot)

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	7.2	8.1	10.6	12.7
↓B [1]	8.1	9.1	11.6	13.7
↓H [1]	10.6	11.6	14.0	16.2
↓V [2]	12.7	13.7	16.2	18.3

Efficacy, 3500K, 80 CRI (Lumens Per Watt)

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	103	105	107	108
↓B [1]	100	102	105	106
↓H [1]	95	97	100	102
↓V [2]	92	94	97	99

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**) / Standard Output (**S**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 4546 lm x 0.789 = 3587 lm

Total Light Output per Foot: 1137 lm/ft x 0.789 = 897 lm/ft.

watts/foot: 10.6 W/ft.

Efficacy = $\frac{897\ \frac{\text{lm}}{\text{ft.}}}{10.6\ \frac{\text{W}}{\text{ft.}}}$ = 85 lm/W

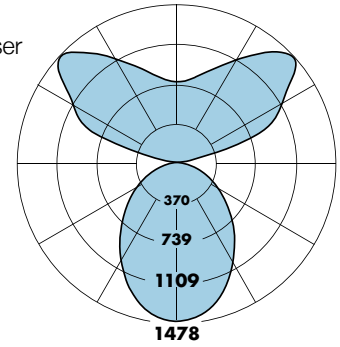
S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 90352

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Indirect/Direct Photometry - 4' Luminaire 3500K

HP2-P-ID-V-V-835-F-WSO
Uplight: Widespread Optic / **Downlight:** Regressed Diffuser



Distribution: 55% Up (**V**) / 45% Down (**V**)
Efficacy: 101 lm/W
Uplight: 4018 lumens (1005 lumens/foot)
Downlight: 3312 lumens (828 lumens/foot)
Total luminaire output: 7330 lumens (1833 lm/ft)
72.5 watts (18.1 W/ft)
Peak Candela Value: 1457 @ 135°
CRI: 80 / CCT: 3500K
ITL LM79 Report 89456

CANDELA DISTRIBUTION

	0.0	22.5	45	67.5	90	Flux
0	1461	1461	1461	1461	1461	
5	1451	1450	1448	1447	1447	137
15	1376	1362	1359	1348	1342	381
25	1224	1204	1187	1165	1153	545
35	1023	998	973	942	929	608
45	793	773	749	717	705	576
55	568	557	535	509	499	478
65	364	356	344	328	322	341
75	187	186	180	174	170	191
85	49	49	48	46	45	54
90	0	0	0	0	0	
95	47	83	83	69	68	92
105	183	258	532	556	458	434
115	324	409	720	993	1048	694
125	460	542	887	1257	1299	793
135	558	634	907	1299	1457	741
145	633	693	885	1127	1236	572
155	694	728	843	963	1012	393
165	736	749	793	837	853	226
175	756	758	763	768	770	73
180	759	759	759	759	759	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	3001 (↑55% I 45%↓)	3424 (↑60% I 40%↓)	4481 (↑70% I 30%↓)	5374 (↑75% I 25%↓)
↓B [1]	3349 (↑49% I 51%↓)	3772 (↑55% I 45%↓)	4830 (↑65% I 35%↓)	5722 (↑70% I 30%↓)
↓H [1]	4221 (↑39% I 61%↓)	4644 (↑44% I 56%↓)	5701 (↑55% I 45%↓)	6594 (↑61% I 39%↓)
↓V [2]	4957 (↑33% I 67%↓)	5380 (↑38% I 62%↓)	6437 (↑48% I 52%↓)	7330 (↑55% I 45%↓)

Light Output, 3500K, 80 CRI (Lumens Per Foot)

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	750	856	1120	1343
↓B [1]	837	943	1207	1431
↓H [1]	1055	1161	1425	1649
↓V [2]	1239	1345	1609	1833

Power, 3500K (Watts Per Foot)

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	7.1	8.1	10.5	12.6
↓B [1]	8.1	9.0	11.5	13.6
↓H [1]	10.5	11.5	13.9	16.0
↓V [2]	12.6	13.6	16.0	18.1

Efficacy, 3500K, 80 CRI (Lumens Per Watt)

	↑S [1]	↑B [1]	↑H [1]	↑V [2]
↓S [1]	106	106	107	107
↓B [1]	104	105	105	105
↓H [1]	100	101	102	103
↓V [2]	98	99	100	101

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**) / Standard Output (**S**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 4481 lm x 0.789 = 3536 lm

Total Light Output per Foot: 1120 lm/ft x 0.789 = 884 lm/ft.

watts/foot: 10.6 W/ft.

Efficacy = $\frac{884\ \frac{\text{lm}}{\text{ft.}}}{10.5\ \frac{\text{W}}{\text{ft.}}}$ = 84 lm/W

S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

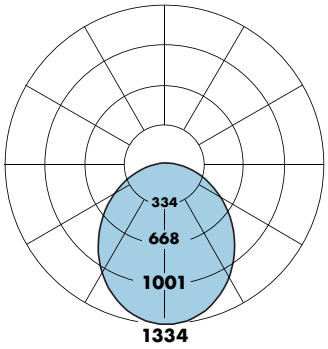
[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 89456

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Direct Photometry - 4' Luminaire 3500K

HP2-WM-D-4'-V-835
Downlight: Flush Diffuser

Efficacy: 87 lm/W
Total luminaire output: 3215 lumens (804 lm/ft)
36.9 watts (9.2 W/ft)
Peak Candela Value: 1334 @ 0º
CRI: 80 / CCT: 3500K
ITL LM79 Report 85136



CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	FLUX
0	1334	13334	1334	1334	1334	
5	1327	1326	1326	1325	1324	126
15	1236	1252	1251	1244	1236	352
25	1133	1117	1109	1088	1075	508
35	958	942	923	896	887	576
45	762	747	725	697	686	558
55	563	551	532	509	500	475
65	374	365	351	337	331	349
75	206	201	195	188	184	207
85	62	61	59	57	57	66
90	0	0	0	0	0	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire			
S [1]	**B** [1]	**H** [1]	**V** [2]
1316	1655	2501	3215

Light Output, 3500K, 80 CRI (Lumens Per Foot)			
S [1]	**B** [1]	**H** [1]	**V** [2]
329	414	625	804

Power, 3500K (Watts Per Foot)			
S [1]	**B** [1]	**H** [1]	**V** [2]
3.6	4.6	7.1	9.2

Efficacy, 3500K, 80 CRI (Lumens Per Watt)			
S [1]	**B** [1]	**H** [1]	**V** [2]
91	90	88	87

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 2501 lm x 0.789 = 1973 lm

Total Light Output per Foot: 625 lm/ft x 0.789 = 493 lm/ft.

watts/foot: 7.1 W/ft.

$$\textbf{Efficacy} = \frac{493\ \frac{\text{lm}}{\text{ft.}}}{7.1\ \frac{\text{W}}{\text{ft.}}} = 69\ \text{lm/W}$$

S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

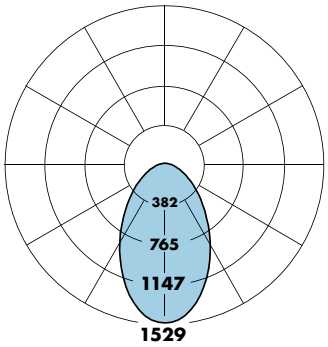
[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 85136

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Direct Photometry - 4' Luminaire 3500K

HP2-WM RG-D-V-835
Downlight: Regressed Diffuser

Efficacy: 79 lm/W
Total luminaire output: 2887 lumens (722 lm/ft)
36.7 watts (9.2 W/ft)
Peak Candela Value: 1529 @ 0º
CRI: 80 / CCT: 3500K
ITL LM79 Report 90350



CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	Flux
0	1529	1529	1529	1529	1529	
5	1520	1518	1513	1507	1504	143
15	1443	1412	1370	1327	1309	385
25	1293	1224	1131	1049	1017	523
35	1086	993	862	757	722	550
45	855	749	608	511	482	490
55	624	516	392	322	305	380
65	212	141	103	95	94	131
75	212	141	103	95	94	131
85	57	32	28	26	26	36
90	0	0	0	0	0	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire			
S [1]	**B [1]**	**H [1]**	**V [2]**
1182	1486	2245	2887

Light Output, 3500K, 80 CRI (Lumens Per Foot)			
S [1]	**B [1]**	**H [1]**	**V [2]**
295	371	561	722

Power, 3500K (Watts Per Foot)			
S [1]	**B [1]**	**H [1]**	**V [2]**
3.6	4.6	7.0	9.2

Efficacy, 3500K, 80 CRI (Lumens Per Watt)			
S [1]	**B [1]**	**H [1]**	**V [2]**
82	81	80	79

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 2245 lm x 0.789 = 1771 lm

Total Light Output per Foot: 561 lm/ft x 0.789 = 443 lm/ft.

watts/foot: 7.1 W/ft.

Efficacy = $\frac{443 \ \frac{\text{lm}}{\text{ft.}}}{7.0 \ \frac{\text{W}}{\text{ft.}}}$ = 63 lm/W

S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

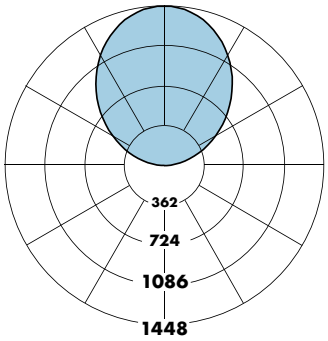
[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 90350

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Indirect Photometry - 4' Luminaire 3500K

HP2-WM I-V-835-F
Uplight: Flush Diffuser

Efficacy: 102 lm/W
Total luminaire output: 3749 lumens (937 lm/ft)
36.7 watts (9.2 W/ft)
Peak Candela Value: 1448 @ 180º
CRI: 80 / CCT: 3500K
ITL LM79 Report 85134



CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	Flux
90	0	0	0	0	0	
95	72	73	73	72	72	80
105	245	243	240	236	237	254
115	439	436	433	424	422	427
125	651	644	642	633	632	573
135	868	856	859	849	846	660
145	1074	1061	1062	1056	1051	663
155	1249	1235	1241	1235	1229	570
165	1374	1366	1370	1367	1365	386
175	1439	1439	1439	1439	1439	136
180	1448	1448	1448	1448	1448	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire			
S [1]	**B [1]**	**H [1]**	**V [2]**
1535	1929	2916	3749

Light Output, 3500K, 80 CRI (Lumens Per Foot)			
S [1]	**B [1]**	**H [1]**	**V [2]**
384	482	729	937

Power, 3500K (Watts Per Foot)			
S [1]	**B [1]**	**H [1]**	**V [2]**
3.6	4.6	7.0	9.2

Efficacy, 3500K, 80 CRI (Lumens Per Watt)			
S [1]	**B [1]**	**H [1]**	**V [2]**
107	106	104	102

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 2916 lm x 0.789 = 2301 lm

Total Light Output per Foot: 729 lm/ft x 0.789 = 575 lm/ft.

watts/foot: 7.0 W/ft.

$$\textbf{Efficacy} = \frac{575\ \frac{\text{lm}}{\text{ft.}}}{7.0\ \frac{\text{W}}{\text{ft.}}} = 82\ \text{lm/W}$$

S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

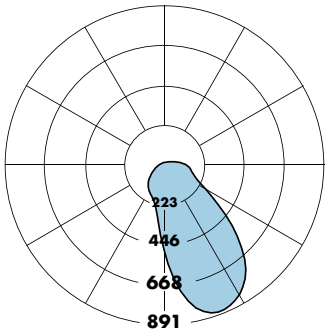
[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 85134

High Performance 2" Aperture (HP-2)
Wall Mount and Arm Mount

Wall Wash Direct Photometry - 4' Luminaire 3500K

HP2-AM-WW-D-K-V-835
Downlight: With Kicker

Efficacy: 77 lm/W
Total luminaire output: 1500 lumens (375 lm/ft)
19.6 watts (4.9 W/ft)
Peak Candela Value: 882 @ 25°
CRI: 80 / CCT: 3500K
ITL LM79 Report 85137



CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	FLUX
0	485	485	485	485	485	
5	652	606	483	378	342	47
15	863	790	470	251	219	145
25	882	829	442	201	184	231
35	795	764	397	168	152	282
45	581	629	333	133	105	277
55	326	436	251	86	62	217
65	196	250	167	43	24	144
75	158	145	88	7	0	87
85	124	97	24	0	0	50
90	93	68	0	0	0	

Total Light Output, 3500K, 80 CRI (Lumens) - 4' Luminaire			
S [1]	**B [1]**	**H [1]**	**V [2]**
614	772	1167	1500

Light Output, 3500K, 80 CRI (Lumens Per Foot)			
S [1]	**B [1]**	**H [1]**	**V [2]**
154	193	292	375

Power, 3500K (Watts Per Foot)			
S [1]	**B [1]**	**H [1]**	**V [2]**
2.0	2.5	3.8	4.9

Efficacy, 3500K, 80 CRI (Lumens Per Watt)			
S [1]	**B [1]**	**H [1]**	**V [2]**
76	77	77	77

Sample Lumen Adjustment Calculation

Lumen Adjustment Factors 80 CRI	
3000K	0.985
3500K	1.000
4000K	1.032

Lumen Adjustment Factors 90 CRI	
3000K	0.746
3500K	0.760
4000K	0.789

High Output (**H**), 4000K, 90 CRI

Lumen Adjustment Factor: 0.789

Total Light Output: 1167 lm x 0.789 = 921 lm

Total Light Output per Foot: 292 lm/ft x 0.789 = 230 lm/ft.

watts/foot: 3.8 W/ft.

Efficacy = $\frac{230 \ \frac{\text{lm}}{\text{ft.}}}{3.8 \ \frac{\text{W}}{\text{ft.}}}$ = 60.5 lm/W

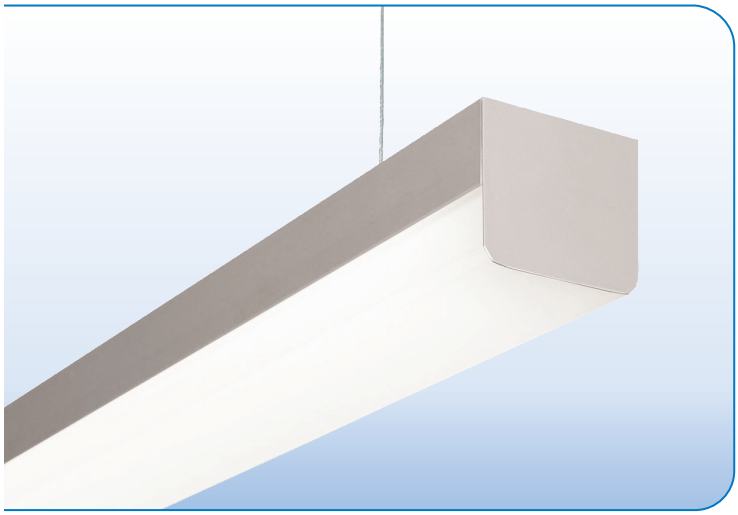
S - Standard Output, B - Boosted Standard Output, H - High Output, V - Very High Output

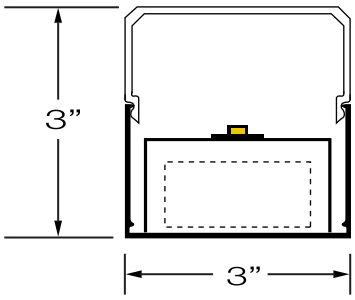
[1] Family Correlation based on 4' luminaire 3500K Very High Output (**V**) test - 120V.
[2] Based on ITL report: 85137

PRIMUS LIGHTING

Luminaire **WB**
Linear lensed

SURFACE MOUNT





SPECIFICATIONS

HOUSING	Extruded aluminum housing up to 12’ long. Continuous runs available.
FINISH	Satin anodized or white paint finish standard. Custom finish optional.
LENS	Extruded DR acrylic, snap-on frosted widespread lens.
LED DRIVER	Integral, universal voltage; 0-10V dimming standard; 1% dimming optional.
K/O’s	Optional. 1/2” Back service hole provided for surface mount when using blank endcaps only.
MOUNTING	SURFACE MOUNT: Mounting holes pre-drilled. See page 2 for details.
	CABLE SUSPENDED: Aircraft cable suspention kit (SK), canopy and prewired with 16/5 SVT cord.
LED’s	60,000 hours. (L70), High uniformity, 85 CRI, by Nichia and Cree.
CERTIFICATION	ETL/CSA listed for damp locations. ETL 2001431 MADE IN THE USA

LED COLOR & LUMEN OPTIONS

		LUMENS PER FOOT – WATTS PER FOOT – LUMENS PER WATT		
LED COLOR	CRI	LOW	MEDIUM	HIGH
WHITE 2700K	85	458 L/FT 3.9 W/FT 117 L/W	850 L/FT 7.9 W/FT 107 L/W	1149 L/FT 11.5 W/FT 100 L/W
WHITE 3000K	85	474 L/FT 3.9 W/FT 121 L/W	878 L/FT 7.9 W/FT 111 L/W	1187 L/FT 11.5 W/FT 103 L/W
WHITE 3500K	85	487 L/FT 3.9 W/FT 124 L/W	903 L/FT 7.9 W/FT 114 L/W	1221 L/FT 11.5 W/FT 106 L/W
WHITE 4000K	85	497 L/FT 3.9 W/FT 126 L/W	920 L/FT 7.9 W/FT 116 L/W	1244 L/FT 11.5 W/FT 108 L/W

Values include .85 driver efficiency factor. Higher lumen packages available.

NOMINAL LENGTH	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'
ACTUAL LENGTH	14"	23"	34"	49"	56"	73"	89"	97"	111"	121"	133"	145"

PART NUMBER

SERIES
ALX1-SQL-LED

LUMENS
- **L** LOW
- **M** MEDIUM
- **H** HIGH
- **CP** CUSTOM PROGRAMMED (Specify Lumens/FT or Watts/FT)

COLOR
- **27K** 2700K
- **3K** 3000K
- **35K** 3500K
- **4K** 4000K

VOLTS
- **UNV** (120/277) 10% DIM
- **UNV 1%** (120/277) 1% DIM

MOUNTING

SURFACE MOUNT
- **SM** SURFACE MOUNT
- **JBP** J BOX PLATE

CABLE SUSPENDED
- **SK36** 36” CABLE KIT
- **SK72** 72” CABLE KIT

ENDCAP STYLE

STANDARD ENDCAP
- **SEB** BLANK ENDS
- **SEK** ONE END K/O
- **SBEK** BOTH ENDS K/O

ARCHITECTURAL ENDCAP
- **AEB** BLANK ENDS

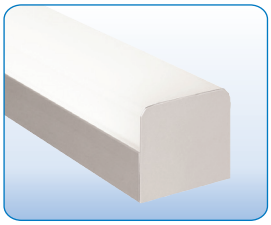
OPTIONS
- **MS** MOTION SENSOR
- **MSP** BI-LEVEL MOTION SENSOR

EM PACKS
- **EM1** 800 LUMEN
- **EM2** 1400 LUMEN

FINISH
- **S** SATIN
- **W** WHITE
- **C** CUSTOM

LENGTH
- 1’ 7’
- 2’ 8’
- 3’ 9’
- 4’ 10’
- 5’ 11’
- 6’ 12’

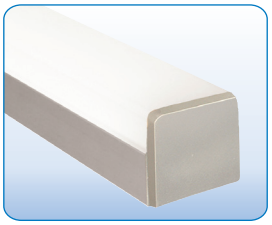
ENDCAP STYLE & OPTIONS



STANDARD ENDCAP

K/O OPTIONS

SEB BLANK ENDS
SEK ONE END K/O+
SBEK BOTH END K/O+

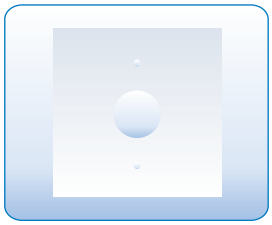


ARCHITECTURAL ENDCAP

AEB BLANK ENDS
3/16" PLATE ENDCAP++
1/2" BACK SERVICE HOLE

MOTION SENSOR

MS MOTION SENSOR
MSP PROGRAMMABLE BI-LEVEL MOTION/LIGHT SENSOR
MOUNTS UNDER LENS
ADDS 3" TO FIXTURE LENGTH



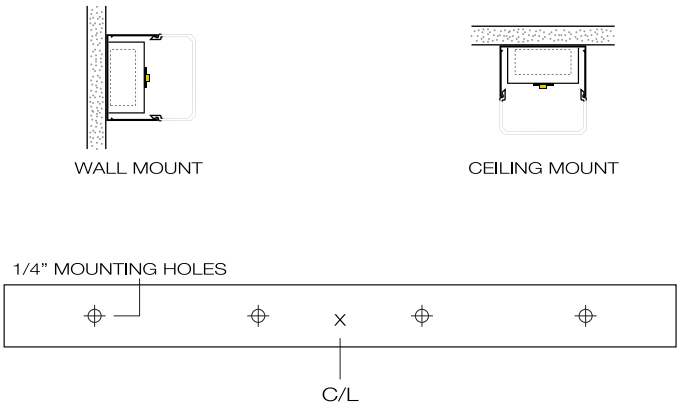
J-BOX PLATE

JBP 5" FLAT CANOPY PLATE TO COVER J-BOX

\+ Easy Row Mounting
++ Consult Factory for Row Mounting

MOUNTING DETAILS

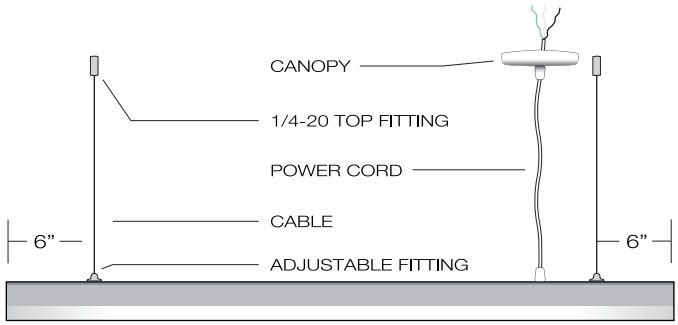
SURFACE MOUNT



- 1/4" Mounting holes provided evenly spaced on back channel.
- 1/2" Back center service hole for snap-in connector provided for surface mount applications when using standard blank endcap or architectural endcap.
- 1' and 2' fixtures require off center service hole (field drill) due to 12" driver

Note: Narrow housing will not cover recessed J-Box. Whip feed recommended. Use optional "JBP" canopy for J-Box mount.

CABLE SUSPENDED



SK36 36" Suspension Kit
SK72 72" Suspension Kit
Other cable lengths available.

Suspension Kit includes:
(2) Top Fittings for 1/4-20 Rod
(2) Adjustable Bottom Fittings
(2) Aircraft Cables
(1) Prewired 16/5 White SVT Cord
(1) White Canopy with Mounting Hardware

*Custom pendant spacing available; consult factory

*Lengths over 8' require center cable support

PHOTOMETRICS

CONSULT FACTORY

SLIM18Y USA

RAB

Luminaire **WC**
Exterior area light at Roof Well

12, 18 and 26 Watt SLIM wall packs are ultra efficient and deliver impressive light distribution with a compact low-profile design that's super easy to install as a downlight or uplight.

Color: Bronze

Weight: 4.5 lbs

Driver Info

Type	Constant Current
120V	0.18A
208V	0.09A
240V	0.09A
277V	0.08A
Input Watts	21.3W

LED Info

Watts	18W
Color Temp	3000K (Warm)
Color Accuracy	71 CRI
L70 Lifespan	100,000
Lumens	2,552
Efficacy	119.8 lm/W

Technical Specifications

Listings

UL Listed:

Suitable for wet locations. Suitable for mounting within 1.2m (4ft) of the ground.

ADA Compliant:

SLIM™ is ADA Compliant

IESNA LM-79 & LM-80 Testing:

RAB LED luminaires and LED components have been tested by an independent laboratory in accordance with IESNA LM-79 and LM-80.

Construction

IP Rating:

Ingress Protection rating of IP66 for dust and water

Cold Weather Starting:

Minimum starting temperature is -40°C (-40°F)

Maximum Ambient Temperature:

Suitable for use in 40°C (104°F)

Housing:

Precision die-cast aluminum housing

Mounting:

Heavy-duty mounting bracket with hinged housing for easy installation

Recommended Mounting Height:

Up to 14 ft

Lens:

Tempered glass lens

Reflector:

Specular thermoplastic

Gaskets:

High-temperature silicone

Finish:

Formulated for high durability and long-lasting color

Green Technology:

Mercury and UV free. RoHS-compliant components.

Technical Specifications (continued)

LED Characteristics

LED:

Multi-chip, long-life LED

Color Consistency:

3-step MacAdam Ellipse binning to achieve consistent fixture-to-fixture color

Color Stability:

LED color temperature is warrantied to shift no more than 200K in color temperature over a 5-year period

Color Uniformity:

RAB's range of Correlated Color Temperature follows the guidelines for the American National Standard for Specifications for the Chromaticity of Solid State Lighting (SSL) Products, ANSI C78.377-2017.

Other

Lifespan:

100,000-hour LED lifespan based on IES LM-80 results and TM-21 calculations

Equivalency:

Equivalent to 100W Metal Halide

Patents:

The design of the SLIM™ is protected by patents in U.S. Pat D681,864, and pending patents in Canada, China, Taiwan and Mexico.

HID Replacement Range:

Replaces 100W Metal Halide

Warranty:

RAB warrants that our LED products will be free from defects in materials and workmanship for a period of five (5) years from the date of delivery to the end user, including coverage of light output, color stability, driver performance and fixture finish. RAB's warranty is subject to all terms and conditions found at rablighting.com/warranty.

FTC Country of Origin:

This product was assembled in the USA by RAB using imported components

Buy American Act Compliance:

This product complies with the Buy American Act

Optical

BUG Rating:

B1 U1 G0

Electrical

Driver:

Constant Current, Class 2, 100-277V, 50/60 Hz., 4KV surge protection, 120V: 0.19A, 208V: 0.11A, 240V: 0.10A, 277V: 0.08A

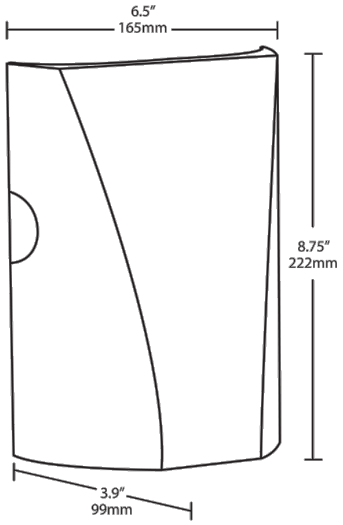
THD:

11% at 120V, 21% at 277V

Power Factor:

99.2% at 120V, 91.5% at 277V

Dimensions



Features

- Full cutoff, fully shielded LED wall pack
- Can be used as a downlight or uplight
- Contractor friendly features for easy installation
- 100,000-hour LED Life
- 5-Year, No-Compromise Warranty

SEAL™

Luminaire **WD**
Linear vaportight
Elevator pit and machine rooms

- Designed for ease of accessibility & mounting
- Available in 2 lengths, 3 wattages & 2 CCT options: 100W (8 ft.), 50W (4 ft.), 25W (4 ft.)
- IP65 Rated
- 0-10V dimming
- 50,000-Hour LED Lifespan
- Available with a factory-installed RAB Lightcloud® control system

Tethers connect the housing to the LED board, allowing for easy, single-person wiring.

Quick, toolless entry access via stainless steel fastening clips.

6 ft, 5-wire cord for easy installation (*included on 8ft models*).

Two mounting options included: V hooks for chain mounting and brackets for surface mounting.

Available with a Lightcloud Controller or Sensor for compatibility with our industry-leading lighting control system.

Performance

100W (8ft)	5000K	4000K
Input Watts	100	100
Lumens	11,698	11,436
Efficacy (Lm/W)	119	118
Color Accuracy (CRI)	82	84

Replaces Up To
(4) F96T12

Energy savings **74%**

50W (4ft)	5000K	4000K
Input Watts	49	48
Lumens	5,849	5,718
Efficacy (Lm/W)	119	119
Color Accuracy (CRI)	82	84

Replaces Up To
(4) F32T8 or **(2) F54T5HO**

Energy savings **61%**

25W (4ft)	5000K	4000K
Input Watts	26	25
Lumens	3,019	2,865
Efficacy (Lm/W)	118	115
Color Accuracy (CRI)	82	85

Replaces Up To
(2) F32T8

Energy savings **60%**

Finish: White

Specifications

UL Listing:
Suitable for wet locations. (Suitable for damp locations only when installed with Lightcloud Sensor).

DLC Listed:
This product is listed by Design Lights Consortium (DLC) and qualifies for rebates from DLC Member Utilities.

IP Rating: IP65, protected against dust and water ingress.

LEDs:
Long-life, high-efficiency, surface-mount LEDs.

Lifespan:
50,000-hour LED lifespan based on IES LM-80 results and TM-21 calculations.

Drivers:
Class 2, Constant Current, 50/60 Hz., 120 - 277V, 2.5kV surge protection

100W: 0.89A@120V, 0.52A@ 208V, 0.45A@ 240V, 0.38A@ 277V
50W: 0.44A@120V, 0.26A@ 208V, 0.23A@ 240V, 0.19A@ 277V
25W: 0.22A@120V, 0.13A@ 208V, 0.11A@ 240V, 0.096A@ 277V

Dimming:
0-10V dimming, standard

Ambient Temperature:
20°C/40° C (-4°F/104°F)

Cold Weather Starting:
The minimum starting temperature is -20°C (-4°F).

Housing:
Impact-resistant polycarbonate with stainless steel door clips. 1/2" opening/drill out for conduit and bushing/cord entry.

Mounting:
Quick-mount, stainless steel snap on brackets supplied for surface mounting. V-Hook brackets supplied standard for suspending the fixture.

Lens:
Diffuse polycarbonate lens for low glare and maximum protection.

Gasket:
High-temperature silicone.

Color Stability:
LED color temperature warrantied not to shift more than 200K in CCT in 5 years.

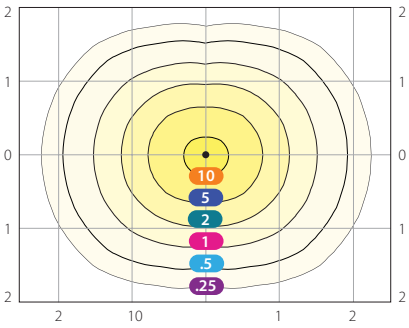
Color Uniformity:
RAB's range of CCT (Correlated Color Temperature) follows the guidelines of the American National Standard for Specifications for the Chromaticity of Solid State Lighting (SSL) Products, ANSI C78.377-2017.

Green Technology:
Mercury and UV free. RoHS-compliant components.

IESNA LM-79 & LM-80 Testing:
RAB LED luminaires have been tested by an independent laboratory in accordance with IESNA LM-79 and LM-80, and have received the Department of Energy "Lighting Facts" label.

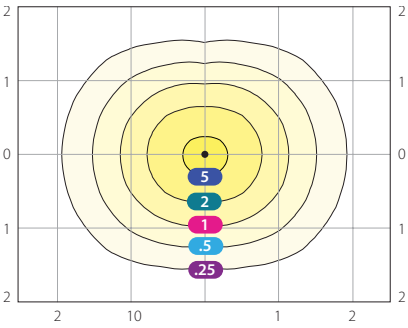
Photometrics

SEAL 100W (8 ft.)
18' Mounting Ht.
5000K
Photometric Report
#RAB03758MOD



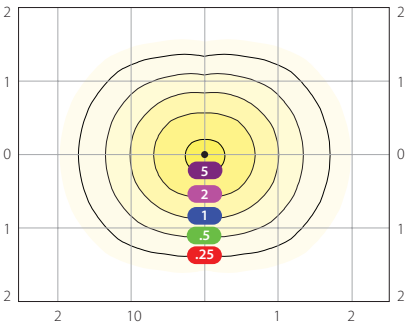
Mounting Height	14	16	18	20	22
Multiplier	1.7	1.3	1.0	0.8	0.7

SEAL 50W (4 ft.)
18' Mounting Ht.
5000K
Photometric Report
#RAB03758



Mounting Height	14	16	18	20	22
Multiplier	1.7	1.3	1.0	0.8	0.7

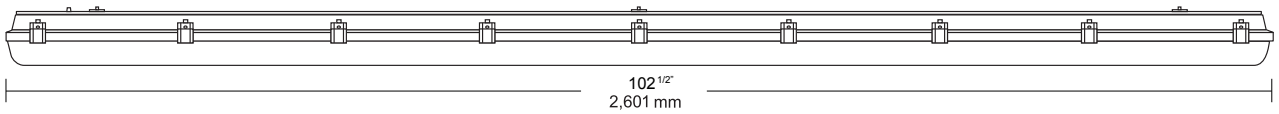
SEAL 25W (4 ft.)
10' Mounting Ht.
5000K
Photometric Report
#RAB04279

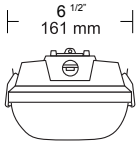


Mounting Height	10	16	18	20	22
Multiplier	1.7	1.3	1.0	0.8	0.7

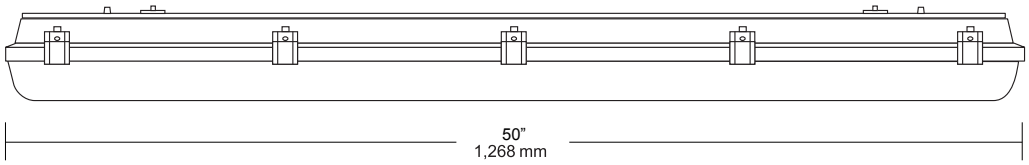
Dimensions & Weights

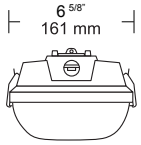
SEAL 100W (8 ft.)
Weight: 19 lbs.



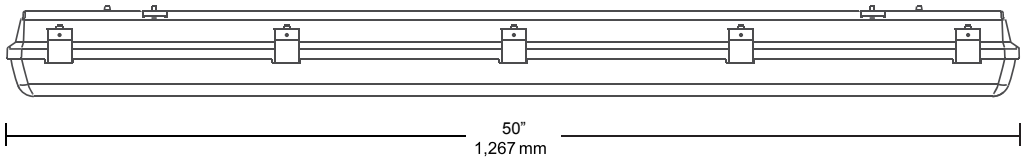


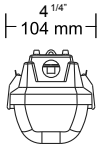
SEAL 50W (4 ft.)
Weight: 7 lbs.





SEAL 25W (4 ft.)
Weight: 5 lbs.





Ordering Information

Product	Length	Wattage	Color Temperature	Driver	Options
SEAL				/D10	

Length		Wattage		Color Temperature		Driver		Options	
8	8ft	**100**	100W (8ft)	**Blank**	5000K	**/D10**	0-10V dimming, 120-277V	**Blank**	No options
4	4ft	**50**	50W (4ft)	**N**	4000K			**/LC**	Lightcloud Controller
		25	25W (4ft)					**/LCS**	Lightcloud Sensor*

**Suitable for damp locations only.*

CHLORIDE
by signify

Exit/Emergency

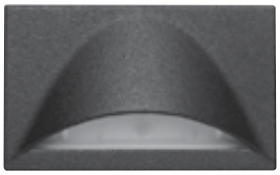
PathMaster

LED die-cast mini step light

Luminaire **WF**
Steplight at Stair A

Option 1 Vertical

Option 2 Horizontal



2.75" x 4.5"

Example: P1SBK

		S		
Series	**Input Voltage**	**Lens**	**Finish**[1]	**Factory Option**
P – PathMaster **PH** – PathMaster Horizontal Mount	**1** – 12V AC,DC **2** – 120 VAC	**S** – Satin	**WH** – White **BK** – Black **A** – Aluminum **BR** – Dark Bronze	**DIM** – Line Voltage Dimmable[2] **AMB** – Amber LEDs **BLU** – Blue LEDs

Footnotes

[1] Custom colors are available. RAL# must be provided.
[2] Line voltage dimmable driver available only with 120 VAC (P2, PH2) models.

codes and standards

- UL 1598 and 924 listed
- UL wet location listed standard
- NFPA 101, NEC, IBC, BOCA, and OSHA illumination standard
- Meets ADA specifications for wall mounted lighting fixtures

construction

- The PathMaster Series is constructed from premium die cast aluminum components and is painted in a durable powder coat finish.
- Numerous standard finishes available with optional finishes available for custom projects.
- PathMaster is assembled as a one-piece device that includes the LED light engine, integral power supply, three level intensity control or line voltage dimmable driver (120 VAC models only).
- All LED and electrical components are protected by both a polycarbonate lens and high impact power supply case that will be located within the junction box.
- A neoprene gasket is provided standard for exterior applications.

installation

- The PathMaster Series is designed for direct mounting to a single gang junction box.
- The PathMaster is fastened to the single-gang junction box via two oval head 6x32x1/2" machine screws (supplied with product); junction boxes are not supplied with the product.
- When installing PathMaster in an outdoor damp or wet location, a single gang "FS" style junction box will be required by most local electrical codes.

electronics

- PathMaster is designed with solid state components and is rated for 10 years of continuous "normally on" use.
- Electrical connection is made via two flying leads.
- Standard product incorporates dip switches on rear of product allowing three levels of intensity. An optional line voltage dimmable driver is available on 120 VAC models. (see factory options)
- The line voltage dimmable driver requires a reverse-phase ELV dimming system.
- Power Consumption

  Current at dip switch setting (low, medium, high)

  12 VDC: 0.140 A, 0.330 A, 0.430 A

  12 VAC: 0.220 A, 0.465 A, 0.585 A

  120 VAC: 0.035 A, 0.065 A, 0.085 A

  120 VAC line voltage dimmable: 60 Hz, 0.072 A
- Standard Wet Location:
  Operating trmperature range -31°F (-35°C) to 104°F (40°C).

lamps

- The PathMaster LED engine utilizes three high performance white LEDs combined with a solid-state integral driver circuit.
- PathMaster performs best when mounted 18" AFF. By utilizing multiple luminaires mounted on 10' centers, PathMaster will meet NFPA required 1 foot-candle average illumination standard.
- PathMaster incorporates a user selectable, three level intensity control or an optional line voltage dimmable driver (120 VAC models only).
- The PathMaster Series with white LEDs operates at 3500K nominal with a minimum CRI of 80. The amber LEDs operate at a nominal wave length of 600nm.

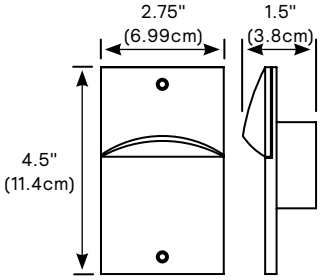
warranty

- Five-year full electronics warranty.

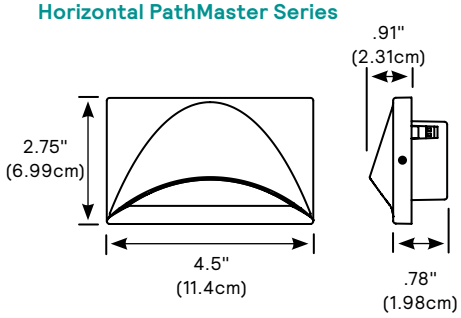
P/PH PathMaster LED die-cast step light

dimensions

PathMaster Series



Horizontal PathMaster Series



lumen output

The following data represents absolute lumen output in accordance with test method IESNA LM-79-08.

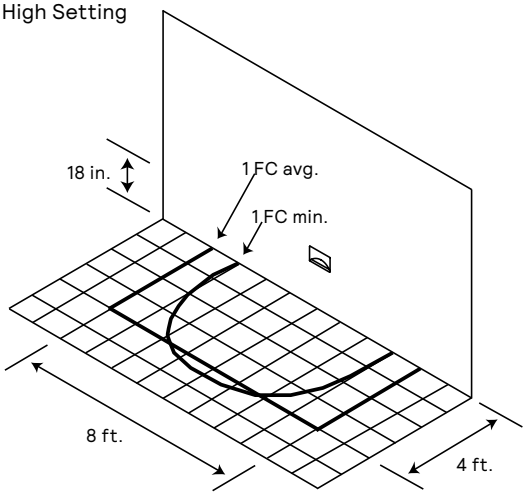
	Vertical, Lumens		
	Low	Med	High
12 VAC/VDC	57.1	123.5	156.0
120 VAC	65.5	123.8	156.0
120 VAC DIM		162.6	

	Horizontal, Lumens		
	Low	Med	High
12 VAC/VDC	54.2	113.1	148.8
120 VAC	62.9	119.3	148.7
120 VAC DIM		128.7	

performance

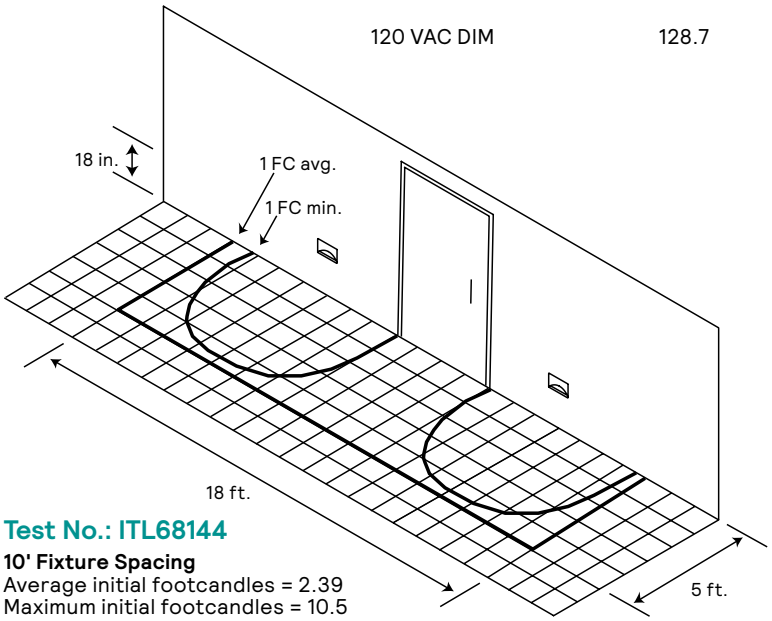
Meets Life Safety Code illumination standard; average of 1.0 FC, no point less than 0.1 FC, max to min ratio of 40:1. Assumes open space with no obstructions, mounting height: 18" and reflectances: 80/50/20. Analysis based on independently tested photometrics.

Wall Mounted 18" AFF
High Setting



Test No.: ITL68144

Average initial footcandles = 3.11
Maximum initial footcandles = 10.1
Minimum initial footcandles = 0.4
Maximum to minimum ratio = 25.25



Test No.: ITL68144

10' Fixture Spacing
Average initial footcandles = 2.39
Maximum initial footcandles = 10.5
Minimum initial footcandles = 0.3
Maximum to minimum ratio = 35.00

Signify North America Corporation
200 Franklin Square Drive,
Somerset, NJ 08873
Telephone 855-486-2216

Signify Canada Ltd.
281 Hillmount Road,
Markham, ON, Canada L6C 2S3
Telephone 800-668-9008

THIS PAGE INTENTIONALLY LEFT BLANK

PCCD – Laney Library LRC

Updated BOD – Acoustics

May 21, 2020

TEECOM
1333 Broadway, Suite 601
Oakland, CA 94612

Peter Holst
peter.holst@teecom.com
McLean Pierce
mclean.pierce @teecom.com
Acoustics

Table of Contents

6. Acoustical Design

6.1 Sound Isolation

A. Partitions

Design criteria for sound isolation of each acoustically sensitive space type is provided below in terms of the Sound Transmission Class (STC) rating.

Space Adjacency	BOD STC
Restroom / Shower	STC 50
IDF/MDF or Electrical Rooms	STC 50
Copy / Print	
IT Deliveries / Receiving	
Coffee	STC 40
Reception / Lobby / Lounge	
Tech Help Desk	
Art Exhibition	
Writing Center	
Circulation	
Tutorial / Computer / Reader Spaces (Open)	
Group Study Room	STC 45
Classroom / Tutorial (Enclosed)	
Shared Offices	
Workrooms	
Private Offices	
Math Testing	STC 50
Instruction Design Suite	
AR Control / Production	
Conference	
Web Design Studio	
Green Screen Studio	Reduced from STC 55+ to STC 50 per program discussion
HD Viewing Room	

1) The following recommendations apply to all acoustical assemblies:

   (a) Metal studs should be spaced 24” on-center for improved acoustical performance.

   (b) Friction fit acoustical batt insulation in all stud cavities.

   (c) Fully seal all partition head, base and junction interfaces with non-hardening acoustical caulk.

   (d) Stagger seams in multi-layer constructions.

   (e) Minimize the number of penetrations in acoustical partitions. Provide a ¼” perimeter around assembly penetrations, then seal airtight with acoustical caulk and, if necessary, foam backer rod.

   (f) Fluted deck junctions should be packed to full depth with high density batt insulation or mineral wool and sealed airtight with elastomeric spray or sealant.

   (g) Offset rough-in boxes by 16” on-center and do not exceed one rough-in box per stud bay.

   (h) Apply putty pads to all rough-in boxes (e.g., electrical, HVAC, AV) to continuously cover the back, knockouts, and conduit stubs. This recommendation applies to in-wall backboxes as well; overlap putty pads as necessary.

   (i) Where back-to-back rough-ins cannot be avoided, box-in the j-box with a minimum of one layer of 5/8”-thick gypsum board and seal airtight with acoustical caulk all seams or openings.

   (j) After cables are installed and pulled, cable tray penetrations and conduits should be tightly packed with dense fire blocks or expanding acoustical foam as needed for fire/smoke, and sealed airtight with non-hardening acoustical caulk.

   (k) At intersections between Type B/C/D partitions and vertical mullions, provide either a pre-fabricated mullion upgrade product, such as the Mull-It-Over Mullion End Caps, or an equivalent field-fabricated version.

   (l) Partial height partitions without gypsum board lids should be avoided; where partial height partitions are necessary around any noise-sensitive spaces, extend partition a minimum of 6” above the ceiling and provide a high CAC ceiling tile in each noise sensitive adjacency. Additional measures may be required.

B. Impact Sound Isolation of Floor Ceiling Assemblies

Acoustical separation of vertically adjacent, enclosed spaces should exceed an IIC 50 rating. Spaces with carpet floor are expected to achieve this performance target without additional mitigation. Where hard surface flooring is proposed, mitigation such as resilient floor underlayment or acoustically isolating ceiling assemblies may be necessary.

C. Doors

Sound-gasketed doors are recommended based on the partition type in which the door is installed. Doors installed in sound rated partitions should adhere to the following recommendations:

1) Brush seals should be avoided at all doors in favor of bulb seals.

2) Drop bottoms should seal at a hard, flat material like tile or wood to provide an effective airtight seal.

3) STC 35 - 40 Partitions – Hollow metal or 1-3/4" solid core wood door with a row of bulb seals at head and jambs, such as the Pemko S-88 or equivalent, and an automatic drop bottom seal, such as the Pemko 411-PKL or equivalent.

4) STC 40 - 45+ Partitions (including all electrical, mechanical, server, and equipment rooms) – Hollow metal or 1-3/4" solid core wood door with double row of bulb seals at head and jambs, and an automatic drop bottom seal, such as the Pemko 411-PKL or equivalent.

5) Double doors should be sealed airtight by including an overlapping or "T" astragal, including gaskets such as the Pemko 352_R, Pemko 355_S, or equivalent.

6.2 Room Acoustics

Reverberation time should be controlled to provide for good speech intelligibility in enclosed spaces and to prevent noise buildup in open spaces. Design criteria for the reverberation time (RT60) at 500Hz is provided in the table below.

Space Type	RT60 @ 500 Hz
Coffee	< 1.0
Reception / Lobby / Lounge	
Tech Help Desk	
Art Exhibition	
Writing Center	
Circulation	
Tutorial / Computer / Reader Spaces (Open)	
Group Study Room	0.7
Classroom / Tutorial (Enclosed)	
Shared Offices	
Workrooms	
Private Offices	
Math Testing	
Instruction Design Suite	
AR Control / Production	
Conference	
Web Design Studio	
Green Screen Studio	
HD Viewing Room	

6.3 Building Systems

A. HVAC Guidelines

Background noise levels due to building mechanical systems should be limited to the recommended Noise Criteria (NC) in the table below.

Values in bold italics have been updated based on a review of the Peralta Community College District - District Material Standards – 2010 Update.

Space Type	Target Sound Level
Restroom / Shower	NC 55
IDF/MDF or Electrical Rooms	NC 45
Copy / Print	
IT Deliveries / Receiving	
Coffee	NC 40
Reception / Lobby / Lounge	
Tech Help Desk	
Art Exhibition	
Writing Center	
Circulation	
Tutorial / Computer / Reader Spaces (Open)	***NC 25****
Group Study Room	NC 35
Classroom / Tutorial (Enclosed)	***NC 30***
Shared Offices	***NC 30***
Workrooms	NC 35
Private Offices	NC 30
Math Testing	
Instruction Design Suite	
AR Control / Production	
Conference	
Web Design Studio	
Green Screen Studio	Reduced to NC 30 per project discussions
HD Viewing Room	

* This criterion is very stringent for the expected use and will likely require prohibitively expensive mitigation for the HVAC system.

1) All service connections (ducts, piping and conduit) should be resiliently isolated from vibration isolated equipment with flexible connections, including canvas bellows for ducts, twin sphere neoprene for piping, and flexible tubing for conduit.

2) Select seismic restraints compatible with the vibration isolation requirements of isolated equipment. Seismic restraints should not create rigid connections between equipment and structural building elements.

3) Do not locate terminal units above rooms rated NC 30 or less, such as patient rooms, exam rooms, and interview rooms. Locate terminal units in corridor and duct into sound-sensitive spaces at the door-wall.

4) Diffusers and return grilles should be rated at least 5 NC points lower than the target maximum NC of the room in which they are located for the scheduled airflow.

5) Open return and air transfers to noise-sensitive rooms require a minimum of two 90-degree internally lined elbows separated by at least 4’ of straight ductwork (or length required to obstruct line of sight between spaces).

6) Locate volume dampers at least 4’ upstream of diffusers or return grilles; taper duct size to avoid reliance on dampers for balancing.

7) Plenum return register “crosstalk” mitigation between spaces with common duct runs should include either:

   (a) 90° lined elbows and a minimum of 6’ horizontal feet (or length required to obstruct line of sight between spaces) lined with 1”-thick internal duct liner.

   (b) A minimum of 5’ flexible duct work at each register and a minimum of 10’ separation between openings.

8) Terminal units should include an acoustical plenum (minimum 5’ of 1” acoustically lined ductwork directly downstream of the unit).

9) Terminal units should be at least 8’ from the first diffuser.

10) FCU/FPB inlets should be oriented away from the nearest ceiling registers.

11) Mechanical equipment should be isolated from building structure per Ch.49 Noise and Vibration Control of the ASHRAE Handbook (Table 47).

12) Maximum allowable duct velocities per recommended background noise levels are outlined below. Air velocities for main ducts are for rectangular duct. Velocity limits are per ASHRAE standards. Some diffusers may require lower velocities to achieve design criteria. Return path velocities typically may be 10% higher than supply.

	Maximum In-Duct Air Velocity (FPM)			
NC Rating	Register Neck	In Shaft	Above Grid Ceiling	Exposed (Open Ceiling)
25	350	1700	1250	950
30	425	2250	1500	1200
35	500	1800	1750	1450
40	560	3100	2100	1700
45	625	3500	2500	2000
50	680	4500	3250	2500

B. Plumbing Guidelines

Avoid routing plumbing through or near noise-sensitive (NC 30 and lower) spaces. For NC 35 to NC 45 spaces, active piping located above a hard lid ceiling should avoid contact between the piping and the ceiling framing. Where active piping is located above an acoustical tile ceiling, lag with insulated limp mass barrier.

1) Plumbing fixture pressures should be limited to 70 psi.

2) Piping should be installed with a minimum 1” clearance from building elements, such as partition studs.

3) Excepting fire sprinkler lines and vent lines, active pipes should be resiliently mounted as follows:

   (a) Pipes 1” in diameter and smaller should be resiliently mounted using Holdrite cushioned products or felt-lined equivalent.

   (b) Pipes greater than 1” diameter should be isolated using Stoneman Trisolator products or equivalent.

4) Vertical riser clamps should be structurally isolated using resilient supports, such as ¾” waffle pads.

5) All penetrations of acoustical partitions should be sealed airtight with non-hardening acoustical caulk and, if necessary, foam backer rod.

6) Plumbing systems shall comply with the following limits outlined by ASHRAE:

Pipe Diameter	Maximum Water Flow Velocity (ft/s)	Maximum Water Flow Rate (GPM)
½”	4	3
2”	4	42
4”	7	277

C. Electrical Guidelines

1) New or existing transformers should operate at or below the average sound levels established by NEMA ST 20-2014.

2) Isolate transformers (≤500 kVA) with captive neoprene mounts equal to Mason BR with minimum 0.20-inch static deflection.

3) All connections (cabling, conduit, etc.) to vibration isolated electrical equipment should be flexible.

4) Avoid wall-mounted transformers. Where wall-mounted electrical panels required, avoid mounting adjacent to occupied spaces.

~ End of Document ~

FIRE & RISK ALLIANCE

Fire Alarm System Basis of Design

Peralta Community College District
Library + Learning Resource Center Project
Laney College Main Campus

Presented to:

Peralta Community College District

Prepared by:

Fire & Risk Alliance, LLC
2551 San Ramon Valley Blvd., Suite 207
San Ramon, CA 94583

May 2020

DRAFT FOR REVIEW AND COMMENT

TABLE OF CONTENTS

1.0 INTRODUCTION

Laney College, located at 900 Fallon St, Oakland, CA, plans to construct a new 3-story building to replace the existing Library. The intent of this project is to replace the existing Library with a facility that combines the Library with a Learning Resource Center ("LRC"). In addition to the traditional Library program, the existing Library facilitates a variety of activities and events. The Learning Resource Center will provide a shared home for various instructional resources that currently occupy spaces scattered across the campus. The new Library + LRC ("LLRC") will be a 3-story building of approximately 70,000 ft^2.

This Basis of Design (BOD) document is included as part of the design development phase of the project and serves as a detailed description of project design decisions and intentions to date based on code analyses and discussions with the Client.

2.0 PROJECT INTENT AND DESCRIPTION

The scope of work includes the installation of a supervised automatic fire alarm system using all new initiating devices and notification appliances, in accordance with the requirements of local codes, the California Fire Code, and applicable NFPA Codes and Standards. System manufacturer shall be Simplex.

A new sprinkler system will be installed in the space. Refer to the Automatic Sprinkler System Basis of Design document for further information. Monitoring provisions for the new automatic wet sprinkler system shall be provided via interconnection to the new fire alarm control panel in the Main Electrical Room.

The following is a summary of the proposed scope of work:

- Provide a new addressable Class B fire alarm system in accordance with NFPA 72 and the design documents.
- Provide one new fire alarm control panel along with code required initiation and notification devices as indicated on the plans.
- Provide site remote annunciator at the main building entrance.
- Provide monitoring means and connection to the new sprinkler system and fire pump.
- Provide new connections for proper monitoring of the fire protection and fire alarm systems.
- Provide equipment and connection to a supervising station monitoring service.

3.0 APPLICABLE STANDARDS

The City of Oakland requires addressable fire alarm system designs and installations to comply with standards published by the National Fire Protection Association (NFPA) and the California

Code of Regulations. Specifically, fire alarm systems are required to conform to the requirements of NFPA 72, *National Fire Alarm and Signaling Code*, 2016 edition. The project is intended to comply with the following reference codes and standards:

1) City of Oakland Fire Code
2) California Fire Code – 2019 Edition
3) California Building Code – 2019 Edition
4) NFPA 13, *Standard for the Installation of Sprinkler Systems* – 2016 Edition
5) NFPA 14, *Standard for the Installation of Standpipe and Hose Systems* – 2016 Edition
6) NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection* – 2016 Edition
7) NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* – 2016 Edition
8) NFPA 25, *Standard for Inspection, Testing and Maintenance of Water-Based Fire Protection Systems* – California NFPA 25 Edition (Based on the 2011 Edition)
9) NFPA 70, *National Electric Code* – 2017 Edition
10) NFPA 72, *National Fire Alarm and Signaling Code* – 2016 Edition

4.0 SYSTEM REQUIREMENTS

4.1 Fire Alarm System Narrative

Chapter 2 of the California Fire Code (CFC) defines libraries as an Assembly Group A-3 occupancy. There are additional occupancy classifications that seem suitable for specific areas of the building. Group B occupancies are defined as buildings used for office, professional or service-type transactions, including storage of records and accounts. All educational occupancies for students above the 12th grade are considered to be Group B occupancies. A room or space used for assembly purposes with an occupant load of less than 50 persons and accessory to another occupancy shall be classified as Group B occupancy or as part of that occupancy. A room or space used for assembly purposes that is less than 750 ft^2 in area and accessory to another occupancy shall be classified as a Group B occupancy or as part of that occupancy.

Educational Group E occupancies include the use of a building or structure, or a portion thereof, more than six persons at any one time for educational purposes through the 12th grade.

There are portions of the building which are anticipated to be identified as Group S storage occupancies. It is important to note that a room or space used for storage purposes that is accessory to another occupancy shall be classified as part of that occupancy.

Section 907.2.1 of the CFC requires a manual fire alarm system that activates occupant notification system in accordance with Section 907.5 in Group A occupancies where the occupant load due to the assembly occupancy is 300 or more. Manual fire alarm boxes are not required where the building is equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1 and the occupant notification appliances will activate

throughout the notification zones upon sprinkler water flow. The CFC further explains that every Group A building used for educational purposes shall be provided with a manual or automatic fire alarm system. This provision shall apply to, but shall not necessarily be limited to, every community college and university. In addition, a manual fire alarm system shall be installed in Group B occupancies containing educational facilities.

A manual and automatic fire alarm system that initiates the occupant notification signal utilizing an emergency voice/alarm communication system meeting the requirements of Section 907.5.2.2 and installed in accordance with Section 907.6 shall be installed in Group E occupancies with an occupant load of 50 or more persons or containing more than one classroom or one or more rooms used for Group E purposes. As there are areas of the building with the potential to be Group E occupancies, an emergency voice/alarm communication system will be provided throughout the building.

Based on these occupancy classifications, a new automatic, supervised, Class B addressable fire alarm system shall be installed in the new building. The fire alarm system shall annunciate alarm, pre-alarm, trouble and supervisory conditions in accordance with the applicable codes. As part of this project, new devices shall be provided for monitoring of the new fire alarm system, automatic wet sprinkler system, and fire pump.

Section 907.2 of the CFC states that no fewer than one manual fire alarm box shall be provided in an approved location to initiate a fire alarm signal for fire alarm systems employing automatic fire detectors or waterflow detection devices. Where other sections of this code allow elimination of fire alarm boxes due to sprinklers, or automatic fire alarm systems, a single fire alarm box shall be installed at a location approved by the enforcing agency. The location of the manual fire alarm box will be chosen based on discussions with the Client and fire officials.

New detection devices shall be provided in the areas indicated on the design drawings. Complete audible notification shall be provided throughout the building in addition to visual notification appliances in all common areas as per the requirements of Section 907.5.2.3.1 of the CFC. All occupant notification throughout the building shall comply with Section 907.5 of the CFC.

The fire alarm system shall be interconnected to monitor the fire pump and associated appurtenances. Monitoring means shall also be provided for all control valves, flow switches, etc. in the automatic sprinkler system.

The fire alarm system will be connected to, and monitored by, an approved supervising station monitoring system. The remote station connection shall be accomplished via two dedicated phone lines. Alarm, supervisory and trouble signals shall be distinctly and descriptively different, transmitted to the control panel, local annunciator and automatically transmitted to an approved remote supervising station, or proprietary supervising station as defined in NFPA 72. When approved by the Fire Code Official, signals may sound an audible signal at a constantly attended location.

Work required for this project will be identified on the fire alarm design drawings and in the project specifications.

4.2 Remote Annunciator Panel

A remote annunciator panel shall be provided to indicate detection activation and waterflow conditions. Annunciator shall be installed at the main entrance and shall be visible to approaching emergency personnel. The remote annunciator panel shall be Simplex 4100U, based on the Peralta Community College District Material Standards.

4.3 Auxiliary Power (A.C.) Circuit Connection

The new fire alarm panel will be connected to a dedicated auxiliary power (A.C.) circuit. A.C. circuit is to be 120VAC.

4.4 Lightning Protection

All exterior fire alarm circuits and 120 VAC circuits shall be provided with lightning/surge protection in accordance with NFPA and manufacturer requirements.

4.5 Initiation and Supervisory Devices

The fire alarm system consists of alarm initiating devices and supervisory devices. The alarm initiating devices include spot-type smoke detectors, sprinkler system waterflow switches, and manual pull stations. Supervisory devices include sprinkler tamper switches and duct smoke detectors. Each initiating and supervisory device will have a unique address. The operation of general initiating devices (sprinkler water flow, system smoke detector, or manual fire alarm pull station) will sound the alarm throughout the entire building. Supervisory devices will sound an audible alarm at the fire alarm control panel (FACP) but will not activate the notification appliances. All alarm, supervisory and trouble signal indications should send a signal to the central station monitoring system.

System smoke detectors shall be addressable photoelectric smoke detectors. Smoke detectors shall be installed within listed spacing of all fire alarm control equipment including annunciators, fire alarm control panels and notification appliance circuit panels in accordance with NFPA 72. Smoke detectors shall be installed in the areas indicated on the drawings and as required by the applicable codes. Smoke detector activation shall initiate a general alarm.

Sprinkler system waterflow switches (where applicable) will be monitored.

Duct smoke detectors shall be installed and shall be listed for the air velocity, temperature and humidity present in the duct. Activation of a duct smoke detector shall initiate a visible and audible supervisory signal at a constantly attended location and shall perform the intended fire safety function. The location of duct detectors shall comply with Section 6.4.2 of NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems.* All necessary interface functions to cause the operation of HVAC systems, smoke dampers, fire dampers, fan controls, etc. will be included.

At this time, the intent is to equip the building elevators with shunt trip. For this reason, heat detectors shall be provided at the top of elevator hoistways and within the elevator control room on the roof to initiate firefighter hat signal. Heat detectors shall activate before the activation of elevator hoistway sprinklers to initiate elevator power shunt trip. Heat detectors used to shut down elevator power prior to sprinkler operation shall be placed within 24 in. of each sprinkler

and be installed in accordance with the requirements of Chapter 17 of NFPA 72. Smoke detectors shall be located in the elevator lobbies and shall be located on the ceiling within 21 ft. of the centerline of each elevator door to initiate Phase I emergency recall operation. Initiation of these detectors shall provide a signal to the fire alarm control panel which shall be interfaced with the appropriate elevator controls to signal elevator recall to the designated level. Emergency control function interface devices shall be located within 3 ft. of the component controlling the emergency control function. Detection scheme shall be programmed such that all elevators will recall to 1st floor upon activation of any system smoke detector except for devices located on 1st floor. Elevators shall recall to 2nd floor upon activation of any 1st floor system smoke detector.

A single manual pull station shall be installed at an approved location within the building. The manual pull station shall be mounted such that the operable part of the manual pull station is not less than 42" and not more than 54" above the finished floor. The manual pull station activation shall initiate a general alarm.

4.6 Notification Appliances

Notification will be provided via a zoned signaling system comprised of electronic speaker and strobe notification appliances. Audible notification appliances will be provided throughout the facility via speaker appliances. Emergency voice/alarm communication systems required by the CFC shall be designed and installed in accordance with NFPA 72. The operation of any automatic fire detector, sprinkler waterflow device or manual fire alarm box shall automatically sound an alert tone followed by voice instructions giving approved information and directions for a general or staged evacuation in accordance with the building's fire safety and evacuation plans. The emergency voice/alarm communications system shall be provided with emergency power in accordance with Section 1203. The system shall be capable of powering the required load for a duration of not less than 24 hours, as required in NFPA 72.

Visible notification appliances are to be provided in all common areas according to the requirements of the CFC. Notification appliances will be installed in accordance with proper candela ratings and spacing requirements. The Peralta Community College District Material Standards specifically require audible notification devices in each classroom and strobes in electrical/telecommunication rooms.

All appliances required to be installed on the exterior of the building shall be weatherproof including all associated conduit. In unheated areas or areas with harsh environments, weatherproof notification appliances are to be installed as indicated on the drawings and as required by the applicable codes. In harsh environment areas, conductors supplied for connection to these weatherproof appliances shall be within weather-tight conduit, connectors and junction boxes.

Approved audible devices shall be connected to the automatic sprinkler system. Audible alarm devices shall be provided in a normally occupied area and on the exterior of the building in an approved location. Actuation of the automatic sprinkler system shall activate the building fire alarm system.

4.7 Fire Pump

Supervision of the new fire pump will be provided. The fire alarm systems will audibly and visually indicate supervisory conditions for the fire pump per the requirements of NFPA 20.

4.8 Fire Alarm System Monitoring

The fire alarm system shall transmit distinctly and descriptively different alarm, supervisory and trouble signals to an approved supervising station in accordance with NFPA 72 or, when approved by the Fire Code Official, shall sound an audible signal at a constantly attended location.

The sprinkler system, standpipe system, and fire pump will be monitored by the new fire alarm system. All the sprinkler system valves shall be monitored for valve status. The system shall be capable of being monitored for alarm, trouble and supervisory signals via dry contacts. A general fire alarm point includes any general initiating device located in the building, such as manual pull stations and smoke detectors.

Monitoring points to be provided are outlined below:

- Fire Alarm Operate
- Fire Alarm Trouble
- Fire Alarm Supervisory
- Fire Suppression Operate
- Fire Pump Running
- Fire Pump Fail
- Fire Pump Phase Reversal

Connection shall be provided to the Client approved supervising station. This shall be a central alarm monitoring company approved by the State Fire Code Official or a nationally recognized testing laboratory. All alarm transmitting devices and systems shall be installed and maintained in accordance with nationally recognized standards.

4.9 General Fire Alarm Point

A general fire alarm point includes any initiating device located in the building, such as general manual pull stations and smoke detectors. A general fire alarm point shall generate the following actions:

- Building notification activation (speakers/strobes)
- Fans and dampers deactivated (shutdown/closed) (in active and adjacent alarm zones)
- Activate emergency elevator recall operations

- Report to supervising station
- Display at fire alarm control panel
- Display alarm condition at annunciator

THIS PAGE INTENTIONALLY LEFT BLANK

FIRE & RISK ALLIANCE

Automatic Sprinkler System Basis of Design

Peralta Community College District
Library + Learning Resource Center Project
Laney College Main Campus

Presented to:

Peralta Community College District

Prepared by:

Fire & Risk Alliance, LLC
2551 San Ramon Valley Blvd., Suite 207
San Ramon, CA 94583

May 2020

DRAFT FOR REVIEW AND COMMENT

TABLE OF CONTENTS

1.0 INTRODUCTION

Laney College, located at 900 Fallon St, Oakland, CA, plans to construct a new 3-story building to replace the existing Library. The intent of this project is to replace the existing Library with a facility that combines the Library with a Learning Resource Center ("LRC"). In addition to the traditional Library program, the existing Library facilitates a variety of activities and events. The Learning Resource Center will provide a shared home for various instructional resources that currently occupy spaces scattered across the campus. The new Library + LRC ("LLRC") will be a 3-story building of approximately 70,000 ft^2.

This Basis of Design (BOD) document is included as part of the design development phase of the project and serves as a detailed description of project design decisions and intentions to date based on code analyses and discussions with the Client.

2.0 PROJECT INTENT AND DESCRIPTION

The scope of work includes the design of: a supervised automatic wet-pipe sprinkler system, automatic standpipe system, fire pump and associated appurtenances in accordance with the requirements of local codes, the California Fire Code, and applicable NFPA Codes and Standards. All areas of the building shall be fully sprinklered unless excepted based on the discussions within this document. The building is to be comprised of Type IIB construction.

Monitoring provisions for the new automatic wet sprinkler system shall be provided via interconnection to the new fire alarm control panel in the Main Electrical Room. Refer to the Fire Alarm System Basis of Design for information regarding new initiating devices and notification appliances throughout each fire protection system zone.

The fire protection scope of work will include the design of:

- Complete and operational, automatic wet pipe sprinkler systems in accordance with applicable code.
- A new point of connection to the underground fire water main at the northwest area of the building.
- A complete and operational fire pump to supplement the new automatic sprinkler/standpipe system water supply.
- A connection from the new fire pump to the new automatic wet sprinkler system and standpipe system.
- An Automatic Class I Standpipe system in accordance with the requirements of the California Fire Code.
- An electric drive fire pump assembly with associated appurtenances.

3.0 APPLICABLE STANDARDS

The City of Oakland requires automatic sprinkler system, standpipe system, and fire pump system designs and installations to comply with standards published by the National Fire Protection Association (NFPA) and the California Code of Regulations. Specifically, automatic sprinkler systems are required to conform to the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*. Standpipe systems are required to conform to the requirements of NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*. Fire pump systems are required to conform to the requirements of NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection.* The project is intended to comply with the following reference codes and standards:

1) City of Oakland Fire Code
2) California Fire Code – 2019 Edition
3) California Building Code – 2019 Edition
4) NFPA 13, *Standard for the Installation of Sprinkler Systems* – 2016 Edition
5) NFPA 14, *Standard for the Installation of Standpipe and Hose Systems* – 2016 Edition
6) NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection* – 2016 Edition
7) NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* – 2016 Edition
8) NFPA 25, *Standard for Inspection, Testing and Maintenance of Water-Based Fire Protection Systems* – California NFPA 25 Edition (Based on the 2011 Edition)
9) NFPA 70, *National Electric Code* – 2017 Edition
10) NFPA 72, *National Fire Alarm and Signaling Code* – 2016 Edition

4.0 SYSTEM REQUIREMENTS

4.1 Automatic Wet Sprinkler System Narrative

Chapter 2 of the California Fire Code (CFC) defines libraries as an Assembly Group A-3 occupancy. There are additional occupancy classifications that seem suitable for specific areas of the building. Group B occupancies are defined as buildings used for office, professional or service-type transactions, including storage of records and accounts. All educational occupancies for students above the 12th grade are considered to be Group B occupancies. A room or space used for assembly purposes with an occupant load of less than 50 persons and accessory to another occupancy shall be classified as Group B occupancy or as part of that occupancy. A room or space used for assembly purposes that is less than 750 ft^2 in area and accessory to another occupancy shall be classified as a Group B occupancy or as part of that occupancy.

Educational Group E occupancies include the use of a building or structure, or a portion thereof, more than six persons at any one time for educational purposes through the 12th grade.

There are portions of the building which are anticipated to be identified as Group S storage occupancies. It is important to note that a room or space used for storage purposes that is accessory to another occupancy shall be classified as part of that occupancy.

The City of Oakland amends the California Fire Code to require an automatic sprinkler system throughout all Group A-3, B, E, and S-1 occupancies. Therefore, a new automatic wet sprinkler system shall be provided in the LLRC and shall be fed by a new fire pump with connection to the City supply via a new underground main.

NFPA 13 provides occupancy classifications for sprinkler systems based on the types of hazards to be protected. NFPA 13 provides five (5) classifications for sprinkler hazards: light hazard, ordinary hazard group I, ordinary hazard group II, extra hazard group I, and extra hazard group II.

The new automatic wet sprinkler system shall be designed and installed according to the requirements of NFPA 13. Section A.5.2 of NFPA 13 classifies libraries (except large stack rooms) as light hazard occupancies. However, the explanatory material associated with this section states that "it is not the committee's intent to automatically equate library bookshelves with ordinary hazard occupancies or with library stacks. Typical library bookshelves of approximately 8 ft. (2.4 m) in height, containing books stored vertically on end, held in place in close association with each other, with aisles wider than 30 in. (750 mm) can be considered to be light hazard occupancies. Similarly, library stack areas, which are more akin to shelf storage or record storage, as defined in NFPA 232, should be considered to be ordinary hazard occupancies." At this time, the stacks are roughly 7 ft. in height and provided with aisles wider than 30 in. The number and size of the stacks do not correlate with a "large stack room", therefore, this and all other similar areas of the building are to be considered light hazard occupancies in this design. Storage rooms, mechanical rooms, and similar spaces will be designed as ordinary hazard per the definition of NFPA 13.

4.2 Water Supply Information

A fire hydrant flow test is necessary to establish basic water supply information for the site. A fire hydrant flow test shall be performed in accordance with NFPA 291, *Recommended Practice for Fire Flow Testing and Marking Hydrants*. The test shall yield data for the available static pressure, residual pressure, and flow at the residual pressure. The water flow test data will be obtained from the water district.

4.3 Hydraulic Design Information

Sufficient water supply shall be provided for the sprinkler systems to meet the minimum pressure and flow requirements for proper spray pattern development as detailed by the sprinkler manufacturer. A placard shall be provided at each sprinkler riser. These placards shall outline the hydraulic design details for each individual system.

Figure 11.2.3.1.1 of NFPA 13 reflects design density and minimum area of sprinkler operation for each type of hazard. For this design, a light hazard occupancy requires a density of 0.10 gpm/ft^2 over an area of operation of 1500 ft^2. The design will also account for a total combined inside and outside hose stream of 100 gpm, according to Table 11.2.3.1.2 of NFPA 13. Ordinary

hazard occupancy requires a density of 0.15 gpm/ft^2 over an area of operation of 1500 ft^2. The design will also account for a total combined inside and outside hose stream of 250 gpm, according to Table 11.2.3.1.2 of NFPA 13. Hydraulic calculations will be provided to ensure that the minimum requirements listed above are satisfied.

4.4 Sprinkler Spacing

Maximum coverage areas for sprinklers in light hazard (LH) occupancies are limited to 225 ft^2 area with a maximum spacing of 15 ft. between sprinklers. Sprinkler protection, spaced in accordance with NFPA 13 criteria, will be provided in offices, corridors, and stack rooms.

The distance from sprinklers to walls is allowed to be increased to nine feet in light hazard occupancy rooms having a floor area of less than 800 square feet. However, in all cases, the 225 ft^2 maximum coverage area per sprinkler still applies.

Maximum coverage areas for sprinklers in ordinary hazard (OH) occupancies are limited to an area of 130 ft^2 with a maximum spacing of 15 feet between sprinklers. Sprinkler protection, spaced in accordance with ordinary hazard criteria, will be provided throughout all storage rooms, mechanical rooms, and similar areas.

Consideration shall be made for the spacing and depth of any beams, to provide coverage in accordance with NFPA 13. Other obstructions to sprinkler discharge shall be considered on a case-by-case basis. Additional sprinklers shall be added as needed for compliance with the obstruction requirements if adjusted sprinklers spacing exceeds the defined spacing limitations for the hazard.

Section 8.15.10 of NFPA 13 states that sprinklers shall be permitted to be installed without regard to aisles where clearance between sprinkler deflectors and tops of stacks is 18 in. or more. At this time, the stacks are roughly 7 ft. in height with a clearance well over 18 in. to the ceiling, therefore, sprinklers shall be spaced according to the standard light hazard occupancy requirements listed above.

Per Section 8.3.3 of NFPA 13, sprinklers in light and ordinary hazard occupancies shall be quick-response type as defined in 3.6.4.8. The sprinklers shall be ordinary temperature rated, or appropriate temperature rated based on the area of coverage ambient temperature condition.

Based on the Peralta Community College District Construction and Material Standards, the following shall be applied to this design:

- Corridor sprinkler heads shall be recessed.
- Sprinkler heads shall be Viking, Star, Central, or equivalent.
- Sprinklers shall be heavy duty type and installed either exposed or concealed per Architect's design.
- Student toilet rooms shall be provided with concealed flush to ceiling style heads having a painted cover plate, per Architect's design.

4.5 Special Considerations and Exempt Locations

Areas that do not require sprinkler protection shall be covered in this section. At this time, the intent is to utilize elevator shunt trip in the building. It is important to note that sprinklers will not be required in elevator hoistways/machine rooms provided the requirements of Section 3005.4.1 of the CBC 2016 Edition are met.

Section 903.3.1.1.1 of the CFC details locations that are not required to contain automatic sprinklers, provided an approved automatic fire detection system is installed in these areas. Such areas include:

- Rooms where the application of water, or flame and water, constitutes a serious life or fire hazard.
- A room or space where sprinklers are considered undesirable because of the nature of the contents, where approved by the fire code official.
- Fire service access elevator machine rooms and machinery spaces.
- Machine rooms, machinery spaces, control rooms…
- Spaces or areas in telecommunications buildings used exclusively for telecommunications equipment…
- Solar photovoltaic panel structures with no use underneath.
- Solar photovoltaic panels supported by framing…

There are multiple rooms in the building, such as IDF, electrical rooms, and IT rooms, where it may be undesirable to provide sprinkler protection. Any rooms that are not equipped with sprinkler protection will be based on discussions with the Client and fire officials.

Section 8.15.3 of NFPA 13 requires sprinklers to be installed beneath all stairways of combustible construction. Sprinklers shall be installed at the top of the stair shafts, under the landings at each floor level, and beneath the lowest intermediate landing. The atrium stairway shall be provided with sprinkler parallel to the incline of the stairs.

4.5.1 Glazing

At this time, the intent is to utilize sprinklers to obtain the two-hour equivalent rating for the glass around the atrium. Section 703.4 of the CBC states that, “under the prescriptive fire-resistance requirements of this code, the fire-resistance rating of a building element, component or assembly shall be established without the use of automatic sprinklers or any other fire suppression system being incorporated as part of the assembly tested in accordance with the fire exposure, procedures and acceptance criteria specified in ASTM E 119 or UL 263. However, this section shall not prohibit or limit the duties and power of the building official…” If sprinklers are permitted to obtain the necessary rating, they shall comply with Section 8.15.26 of NFPA 13.

4.5.2 Skylight

Skylights are located in the atrium area. Section 8.5.7 details requirements for protection of skylights based on area and distance between skylights. Section 712.1.15 of the CBC states that skylights and other penetrations through a fire-resistance-rated roof deck or slab are permitted to be unprotected, provided that the structural integrity of the fire-resistance-rated roof assembly is maintained. Unprotected skylights shall not be permitted in roof assemblies required to be fire-resistance-rated in accordance with Section 705.8.6. The supporting construction shall be protected to afford the required fire-resistance rating of the horizontal assembly supported.

4.5.3 Atrium

According to Section 404.3 of the CBC, where the ceiling of the atrium is more than 55 ft. above the floor, sprinkler protection at the ceiling of the atrium is not required. Based on building design documentation, the peak of the atrium area is greater than 55 ft. to the floor, therefore, sprinkler protection will not be required.

4.5.4 Canopies/Terraces

Sprinklers are required to be provided under exterior roofs, canopies, porte-cochere, balconies, decks, or similar projects exceeding 4 ft. in width. Sprinklers shall be permitted to be omitted where the exterior canopies, roofs, porte-cocheres, balconies, decks, or similar projections are constructed with materials that are noncombustible, limited-combustible, or fire-retardant treated wood as defined in NFPA 703.

4.6 Fire Department Connections

The City of Oakland requires a fire department connection to be provided for all buildings. The fire department connection (FDC) is to be provided in a location approved by the fire department and shall be fully visible and recognizable from the street or nearest point of fire department vehicle access. The FDC will supplement the wet sprinkler system in the building and standpipe riser in the exit enclosures. The fire department connection shall be located not more than 100 ft from the nearest fire hydrant connected to an approved water supply. A listed check valve shall be provided on the fire department connection and shall be in an accessible location.

FDC signage shall be installed as required by Section 912.5 of the CFC. A metal sign with raised letters not less than 1 inch in size shall be mounted on the fire department connection. The sign shall read “AUTOMATIC SPRINKLERS AND STANDPIPES.” Threads shall match the local jurisdiction.

4.7 Backflow Preventer

The potable water supply to the automatic sprinkler and standpipe system shall be protected against backflow as required by the *Health and Safety Code Section 13114.7*. A double check valve assembly backflow preventer or equivalent shall be used as required by the City of Oakland and Peralta Community College District Material Standards.

4.8 Automatic Class I Standpipe System

Section 905.3.1 of the CFC requires Class III standpipe systems to be installed in buildings where the floor level of the highest story is located more than 30 feet above the lowest level of fire department vehicle access. However, Class I standpipes are allowed in buildings that are equipped throughout with an automatic sprinkler system. It is anticipated that the northwest stairway enclosure standpipe system will be a combined standpipe and sprinkler riser. The second stairway enclosure will also be equipped with a standpipe to satisfy the 200 ft travel distance requirement of Section 7.3.2.2.1.1 of NFPA 14.

The City of Oakland amends the CFC with the addition of Section 905.1.1 which states that all Class I, II, and III standpipe outlets in multi-storied buildings or buildings with basements shall be installed on intermediate landings between floors. New standpipes will be provided in each of the two exit enclosure stairwells. A two- and one-half-inch hose connection is to be located at the intermediate landings of each floor from the first floor up to the roof as specified in the design drawings. The standpipes will meet the minimum size requirements of Section 7.6 of NFPA 14. The standpipes will be designed to provide 500 gpm at a minimum residual pressure of 100 psi through the two most remote 2-1/2 in. outlets. The minimum flow rate for additional standpipes shall be 250 gpm per standpipe. A single water supply will be provided for the sprinkler system and standpipes. The system will be hydraulically calculated based on the more demanding scenario between the sprinkler and standpipe system.

In buildings where more than one standpipe is provided, the standpipes are required to be interconnected. All details regarding fire suppression standpipe piping installation shall comply with requirements of NFPA 14. Hose threads shall comply with NFPA 1963 and match the City of Oakland fire department hose threads.

4.9 Piping

Based on the Peralta Community College District Construction and Material Standards, sprinkler pipe shall be schedule 40 black steel, ASTM A-135 or A-53, with ductile iron or cast-iron threaded fittings. UL approved grooved fittings and associated couplings may be used. Steel pipe shall be in accordance with 6.3.2, 6.3.3, or 6.3.4 of NFPA 13, depending on the type of end prep. All piping 2-1/2” and larger shall be grooved and all piping smaller than 2-1/2” shall be threaded. Victaulic grooved fittings shall be used for all grooved piping. Grooved pipe with Victaulic grooved flexible couplings shall only be used in certain locations to meet the requirements of NFPA 13. Locations will be provided on the design drawings. All pipe and fittings shall be approved for fire protection use.

All new piping shall be designed and installed according to the hanging, bracing, and restraint of system piping requirements of Chapter 9 of NFPA 13. This shall include the provision of sway bracing to account for all seismic loading on system piping. Locations of all system hangers shall be indicated on the design drawings.

4.10 Alarms

Approved audible devices shall be connected to the automatic sprinkler system. Such sprinkler water flow alarms devices shall be activated by water flow equivalent to the flow of a single sprinkler of the smallest orifice size installed in the system. Alarm devices shall be provided in a

normally occupied area and on the exterior of the building in an approved location. Actuation of the automatic sprinkler system shall activate the building fire alarm system.

4.11 Valves

Each riser, standpipe system and floor control assembly will be provided with an indicating type valve, as required by NFPA 13, such that all portions of the system can be shut down without interfering with the operation of the remainder of the system. All general valves shall be listed for fire protection use. Section 6.6.1.3 of NFPA 13 states that all valves controlling connections to water supplies and to supply pipes to sprinklers shall be listed indicating valves.

Each floor control valve shall be provided with a sign providing all hydraulic design information for the corresponding floor. A permanently marked weatherproof metal or rigid plastic sign secured with corrosion resistant wire, chain, or other approved means shall be provided.

Check valves will be installed in all water supply sources which include the fire department connections and the main water supply.

A test and drain will be provided at the floor control assembly for each floor. The test connection will be a listed sight test connection with an orifice of the smallest orifice sprinkler installed on that floor. The test connection will terminate at the minimum 2” riser drain in the stairwell.

4.11.1 Fire Pump

A fire pump will be provided to boost the city water supply. The fire pump will be electric engine driven and rated to deliver the required gallons per minute according to the water flow test and hydraulic calculations. The fire pump shall be a vertical in-line pump with associated jockey pump and controller. All pump equipment shall be UL listed as an assembly for fire protection use. The pump will be installed in accordance with NFPA 20.

The pump will have the capability for automatic starting and stopping. Per NFPA 20, the control shall be by means of a pressure- activated switch having independent high and low set points. The switch shall be responsive to water pressure in the fire protection system. Each controller shall have its own individual pressure sensing line. The pressure sensing line connection for each pump shall be made between that pump's discharge check valve and discharge control valve. There shall be no shutoff valve in the pressure sensing line.

A time delay device set for one minute for each 10 horsepower of motor rating to a maximum of seven minutes continuous operation after each start shall be provided.

All pipe sizes related to the fire pump will be indicated on the design drawings.

The fire pump will be located in a dedicated room protected by sprinklers with 1-hour fire-rated construction. The room shall be protected in accordance with Section 913.2.1. Further discussion is required regarding the intended location of the fire pump.

FIRE & RISK ALLIANCE

Fire & Risk Alliance
1801 W. Warner Ave., Suite 301
Chicago, IL 60613
312-981-8889

Job Name	:	Penthouse
Drawing	:	
Location	:	
Remote Area	:	
Contract	:	
Data File	:	Penthouse.WXF

DRAFT

Water Supply Curve C

Calculation includes placeholder city water supply data until flow test results are obtained.

Fire & Risk Alliance
Penthouse

Date

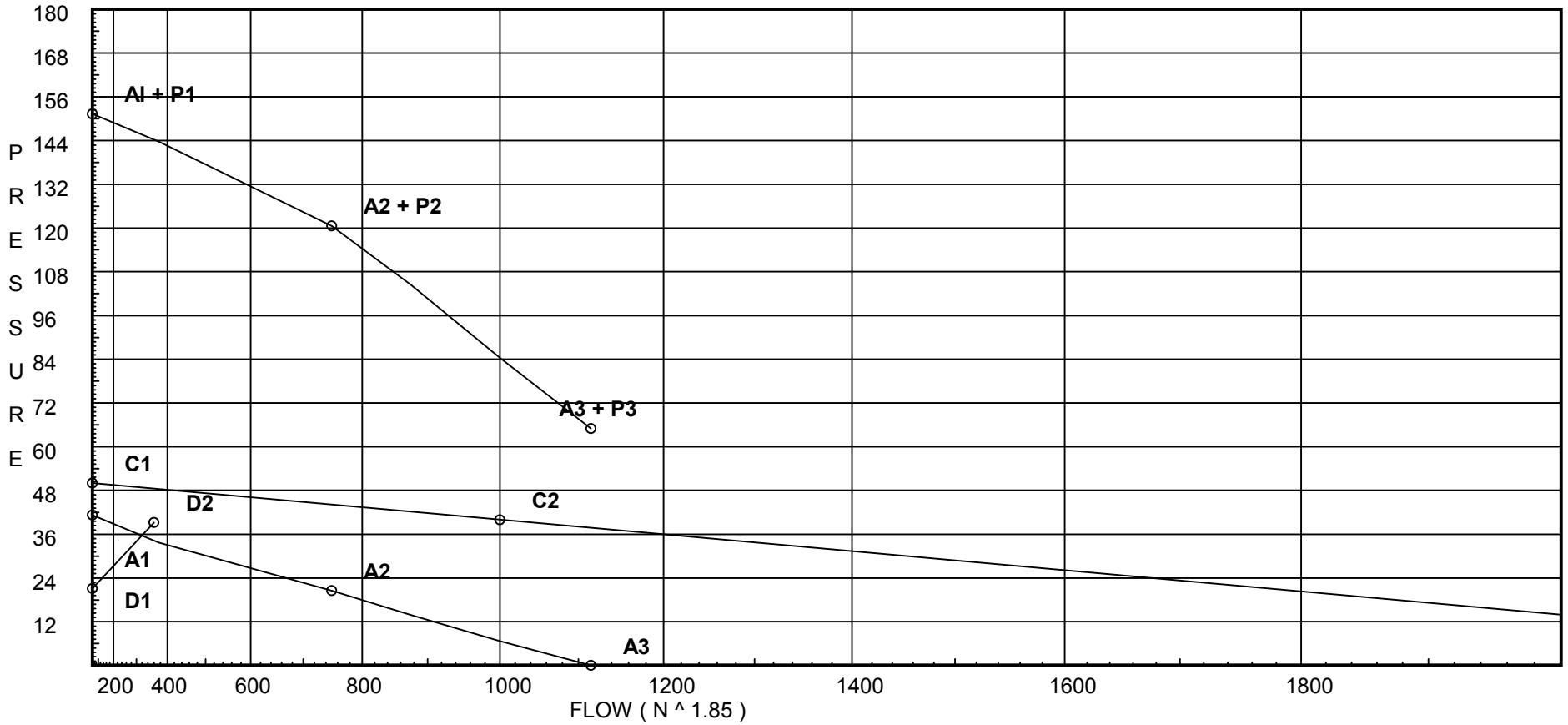
City Water Supply:
- C1 - Static Pressure : 50
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

City Water Adjusted to Pump Inlet for Pf - Elev - Hose Flow
- A1 - Adjusted Static: 41.260
- A2 - Adj Resid : 20.53 @ 750
- A3 - Adj Resid : 0 @ 1115.27

Pump Data:
- P1 - Pump Churn Pressure : 110
- P2 - Pump Rated Pressure : 100
- P2 - Pump Rated Flow : 750
- P3 - Pump Pressure @ Max Flow : 65
- P3 - Pump Max Flow : 1115.27
- City Residual Flow @ 0 = 2386.83
- City Residual Flow @ 20 = 1810.94
- City Water @ 150% of Pump = 37.76

Pump flow terminated at adjusted curve 0 psi

Demand:
- D1 - Elevation : 21.114
- D2 - System Flow : 360.19
- D2 - System Pressure : 39.203
- Hose (Demand) : _____
- D3 - System Demand : 360.19
- Hose (Adj City) : 250
- Safety Margin : 104.957



Fittings Used Summary

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
B	NFPA 13 Butterfly Valve	0	0	0	0	0	6	7	10	0	12	9	10	12	19	21	0	0	0	0	0
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
F	NFPA 13 45' Elbow	1	1	1	1	2	2	3	3	3	4	5	7	9	11	13	17	19	21	24	28
G	NFPA 13 Gate Valve	0	0	0	0	0	1	1	1	1	2	2	3	4	5	6	7	8	10	11	13
S	NFPA 13 Swing Check	0	0	5	7	9	11	14	16	19	22	27	32	45	55	65					
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121
Zih	Wilkins 450	Fitting generates a Fixed Loss Based on Flow																			

Units Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
S8	9.0	11.2	7.2	na	30.05	.15	114	7.2
S7	9.0	11.2	7.5	na	30.68	.15	178	7.2
S6	9.0	11.2	9.24	na	34.04	.15	178	7.2
M6	9.0		11.97	na				
M5	9.0		12.1	na				
M4	9.0		12.36	na				
M3	9.0		12.75	na				
M2	9.0		13.14	na				
M1	9.0		14.86	na				
TR	-4.0		26.62	na				
BR	-30.75		38.39	na				
PO	-30.75		39.2	na				
PI	-30.75		34.17	na				
UG1	-39.75		38.13	na				
UG2	-39.75		38.31	na	250.0			
TEST	-39.75		45.99	na				
S5	9.0	11.2	7.28	na	30.21	.15	88	7.2
S4	9.0	11.2	7.58	na	30.84	.15	138	7.2
S3	9.0	11.2	9.34	na	34.22	.15	138	7.2
S11	9.0	11.2	7.82	na	31.32	.15	115	7.2
L2	9.0		8.4	na				
L1	9.0		10.26	na				
M7	9.0		11.95	na				
S10	9.0	11.2	7.99	na	31.66	.15	180	7.2
S9	9.0	11.2	9.76	na	35.0	.15	182	7.2
S2	9.0	11.2	10.06	na	35.52	.15	138	7.2
S1	9.0	11.2	10.7	na	36.64	.15	138	7.2

The maximum velocity is 15.44 and it occurs in the pipe between nodes L1 and M7

Note: zero elevation point for this calculation
is located at penthouse floor level.

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
S8	30.05	1.61		0.0	8.840	7.200		K Factor = 11.20
to		120.0		0.0	0.0	0.0		
S7	30.05	.0343		0.0	8.840	.303		Vel = 4.74
S7	30.68	1.61		0.0	13.760	7.503		K Factor = 11.20
to		120.0		0.0	0.0	0.0		
S6	60.73	.1262		0.0	13.760	1.736		Vel = 9.57
S6	34.04	1.61	T	8.0	1.520	9.239		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
M6	94.77	.2872		0.0	9.520	2.734		Vel = 14.94
M6	97.98	4.026		0.0	10.000	11.973		
to		120.0		0.0	0.0	0.0		
M5	192.75	.0123		0.0	10.000	.123		Vel = 4.86
M5	95.27	4.026		0.0	10.000	12.096		
to		120.0		0.0	0.0	0.0		
M4	288.02	.0259		0.0	10.000	.259		Vel = 7.26
M4	72.17	4.026		0.0	10.000	12.355		
to		120.0		0.0	0.0	0.0		
M3	360.19	.0391		0.0	10.000	.391		Vel = 9.08
M3	0.0	4.026		0.0	10.000	12.746		
to		120.0		0.0	0.0	0.0		
M2	360.19	.0392		0.0	10.000	.392		Vel = 9.08
M2	0.0	4.026	B	12.0	10.000	13.138		
to		120.0	S	22.0	34.000	0.0		
M1	360.19	.0391		0.0	44.000	1.722		Vel = 9.08
M1	0.0	4.026	5E	50.0	106.730	14.860		
to		120.0		0.0	50.000	5.630		
TR	360.19	.0391		0.0	156.730	6.132		Vel = 9.08
TR	0.0	6.065		0.0	34.000	26.622		
to		120.0		0.0	0.0	11.585		
BR	360.19	.0054		0.0	34.000	.182		Vel = 4.00
BR	0.0	6.065	6E	84.0	34.150	38.389		
to		120.0	G	3.0	119.000	0.0		
PO	360.19	.0053	S	32.0	153.150	.814		Vel = 4.00
	0.0							
	360.19					39.203		K Factor = 57.53
System Demand Pressure						39.203		
Safety Margin						104.957		
Continuation Pressure						144.160		
Pressure @ Pump Outlet						144.160		
Pressure From Pump Curve						-109.990		
Pressure @ Pump Inlet						34.170		
PI	0.0	6.065	G	3.0	8.000	34.170		
to		120.0		0.0	3.000	3.898		
UG1	360.19	.0053		0.0	11.000	.058		Vel = 4.00
UG1	0.0	6.16	2E	40.168	9.000	38.126		
to		140.0		0.0	40.168	0.0		
UG2	360.19	.0037		0.0	49.168	.182		Vel = 3.88
UG2	250.00	6.16	3F	30.126	190.000	38.308		Qa = 250
to		140.0	9E	180.757	215.187	3.698		* * Fixed Loss = 3.698
TEST	610.19	.0098	G	4.304	405.187	3.985		Vel = 6.57

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	*******	Notes	******
			Zih	0.0						
	0.0									
	610.19					45.991		K Factor = 89.98		
S5	30.21	1.61		0.0	8.840	7.276		K Factor = 11.20		
to		120.0		0.0	0.0	0.0				
S4	30.21	.0347		0.0	8.840	.307		Vel = 4.76		
S4	30.84	1.61		0.0	13.760	7.583		K Factor = 11.20		
to		120.0		0.0	0.0	0.0				
S3	61.05	.1273		0.0	13.760	1.752		Vel = 9.62		
S3	34.22	1.61	T	8.0	1.520	9.335		K Factor = 11.20		
to		120.0		0.0	8.000	0.0				
M5	95.27	.2900		0.0	9.520	2.761		Vel = 15.01		
	0.0									
	95.27					12.096		K Factor = 27.39		
S11	31.32	1.61	E	4.0	11.770	7.820		K Factor = 11.20		
to		120.0		0.0	4.000	0.0				
L2	31.32	.0370		0.0	15.770	.584		Vel = 4.94		
L2	31.66	1.61		0.0	13.760	8.404				
to		120.0		0.0	0.0	0.0				
L1	62.98	.1349		0.0	13.760	1.856		Vel = 9.93		
L1	35.00	1.61	E	4.0	1.520	10.260				
to		120.0		0.0	4.000	0.0				
M7	97.98	.3056		0.0	5.520	1.687		Vel = 15.44		
M7	0.0	4.26		0.0	10.000	11.947				
to		120.0		0.0	0.0	0.0				
M6	97.98	.0026		0.0	10.000	.026		Vel = 2.21		
	0.0									
	97.98					11.973		K Factor = 28.32		
S10	31.66	1.61	T	8.0	2.930	7.991		K Factor = 11.20		
to		120.0		0.0	8.000	0.0				
L2	31.66	.0378		0.0	10.930	.413		Vel = 4.99		
	0.0									
	31.66					8.404		K Factor = 10.92		
S9	35.00	1.61	T	8.0	2.930	9.763		K Factor = 11.20		
to		120.0		0.0	8.000	0.0				
L1	35.0	.0455		0.0	10.930	.497		Vel = 5.52		
	0.0									
	35.00					10.260		K Factor = 10.93		
S2	35.52	1.61		0.0	13.760	10.060		K Factor = 11.20		
to		120.0		0.0	0.0	0.0				
S1	35.52	.0467		0.0	13.760	.643		Vel = 5.60		
S1	36.65	1.61	T	8.0	1.520	10.703		K Factor = 11.20		
to		120.0		0.0	8.000	0.0				
M4	72.17	.1735		0.0	9.520	1.652		Vel = 11.37		
	0.0									
	72.17					12.355		K Factor = 20.53		

Fire & Risk Alliance
1801 W. Warner Ave., Suite 301
Chicago, IL 60613
312-981-8889

Job Name	:	Standpipe
Drawing	:	
Location	:	
Remote Area	:	
Contract	:	
Data File	:	Standpipe.WXF

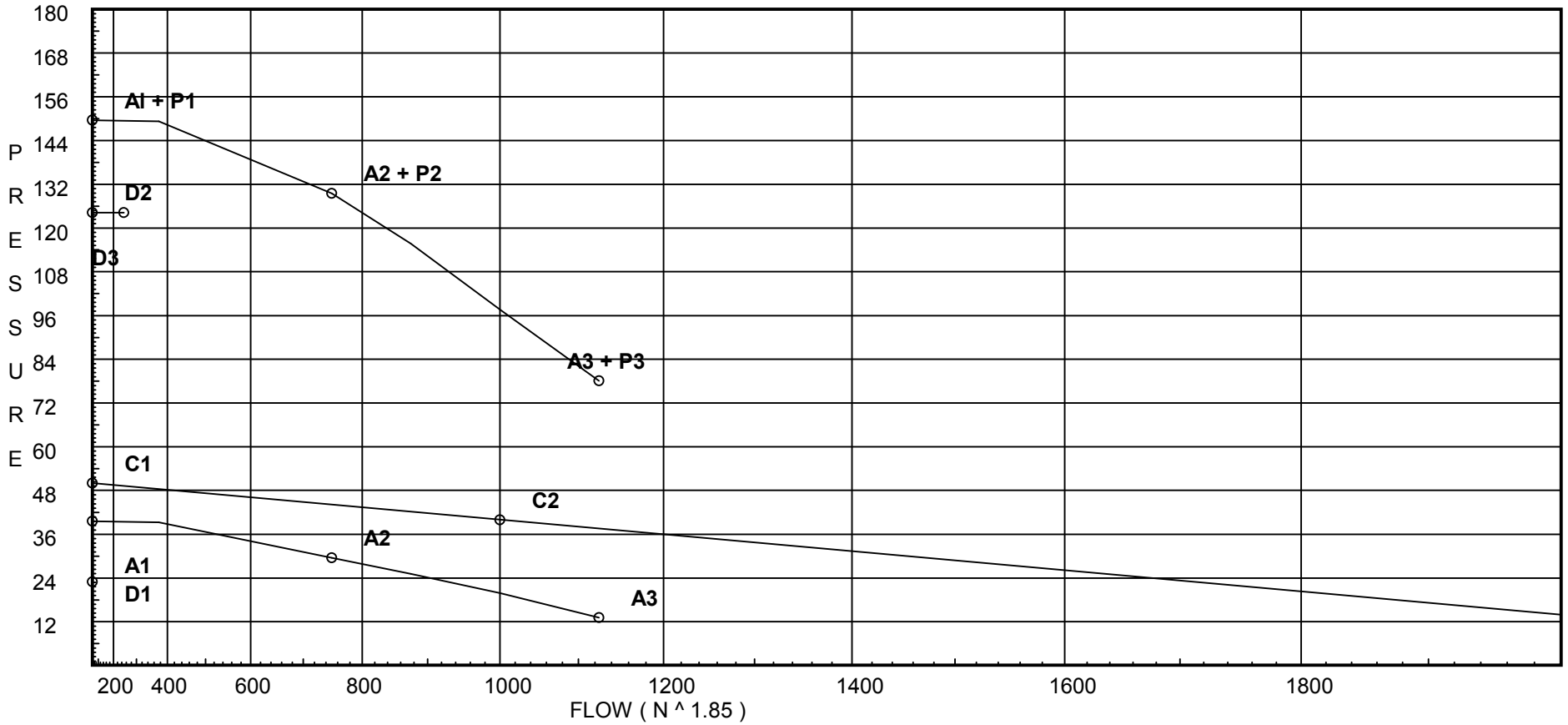
DRAFT

City Water Supply:
- C1 - Static Pressure : 50
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

City Water Adjusted to Pump Inlet for Pf - Elev - Hose Flow
- A1 - Adjusted Static: 39.602
- A2 - Adj Resid : 29.524 @ 750
- A3 - Adj Resid : 13.11 @ 1125

Pump Data:
- P1 - Pump Churn Pressure : 110
- P2 - Pump Rated Pressure : 100
- P2 - Pump Rated Flow : 750
- P3 - Pump Pressure @ Max Flow : 65
- P3 - Pump Max Flow : 1125
- City Residual Flow @ 0 = 2386.83
- City Residual Flow @ 20 = 1810.94
- City Water @ 150% of Pump = 37.57

Demand:
- D1 - Elevation : 22.954
- D2 - System Flow : _____
- D2 - System Pressure : 124.190
- Hose (Demand) : 250
- D3 - System Demand : 250
- Hose (Adj City) : 500
- Safety Margin : 5.334



Fittings Used Summary

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
B	NFPA 13 Butterfly Valve	0	0	0	0	0	6	7	10	0	12	9	10	12	19	21	0	0	0	0	0
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
F	NFPA 13 45' Elbow	1	1	1	1	2	2	3	3	3	4	5	7	9	11	13	17	19	21	24	28
G	NFPA 13 Gate Valve	0	0	0	0	0	1	1	1	1	2	2	3	4	5	6	7	8	10	11	13
S	NFPA 13 Swing Check	0	0	5	7	9	11	14	16	19	22	27	32	45	55	65					
Zih	Wilkins 450	Fitting generates a Fixed Loss Based on Flow																			

Units Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
SPB2	47.5		100.0	na	250.0			
M4	47.5		100.22	na				
M3	31.5		107.46	na				
BRB	18.0		114.28	na				
M1	3.5		123.29	na				
PO	3.5		124.19	na				
PI	3.5		29.52	na				
UG1	-5.5		33.65	na				
UG2	-5.5		34.36	na				
TEST	-5.5		44.13	na				
SPB1	13.5		115.04	na	250.0			
SPA1	31.5		105.64	na	250.0			
BRA	7.5		121.42	na				
M2	3.5		123.25	na				

The maximum velocity is 16.75 and it occurs in the pipe between nodes SPB2 and M4

Note: zero elevation point for this calculation
is located at pump room floor level.

Final Calculations - Hazen-Williams

Fire & Risk Alliance
Standpipe

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
SPB2	250.00	2.469		0.0	1.000	100.000		Qa = 250
to		120.0		0.0	0.0	0.0		
M4	250.0	.2150		0.0	1.000	.215		Vel = 16.75
M4	0.0	4.026		0.0	16.000	100.215		
to		120.0		0.0	0.0	6.930		
M3	250.0	.0199		0.0	16.000	.319		Vel = 6.30
M3	250.00	4.026		0.0	13.500	107.464		
to		120.0		0.0	0.0	5.847		
BRB	500.0	.0717		0.0	13.500	.968		Vel = 12.60
BRB	0.0	6.065	7E	98.0	172.000	114.279		
to		120.0	B	10.0	108.000	6.280		
M1	500.0	.0098		0.0	280.000	2.733		Vel = 5.55
M1	250.00	6.065	S	32.0	8.500	123.292		
to		120.0	G	3.0	35.000	0.0		
PO	750.0	.0206		0.0	43.500	.898		Vel = 8.33
	0.0							
	750.00					124.190		K Factor = 67.30
System Demand Pressure						124.190		
Safety Margin						5.334		
Continuation Pressure						129.524		
Pressure @ Pump Outlet						129.524		
Pressure From Pump Curve						-100.000		
Pressure @ Pump Inlet						29.524		
PI	0.0	6.065	G	3.0	8.000	29.524		
to		120.0		0.0	3.000	3.898		
UG1	750.0	.0207		0.0	11.000	.228		Vel = 8.33
UG1	0.0	6.16	2E	40.168	9.000	33.650		
to		140.0		0.0	40.168	0.0		
UG2	750.0	.0144		0.0	49.168	.708		Vel = 8.07
UG2	0.0	6.16	3F	30.126	190.000	34.358		
to		140.0	9E	180.757	215.187	3.934		* * Fixed Loss = 3.934
TEST	750.0	.0144	G	4.304	405.187	5.835		Vel = 8.07
			Zih	0.0				
	0.0							
	750.00					44.127		K Factor = 112.90
SPB1	250.00	2.469		0.0	1.000	115.044		Qa = 250
to		120.0		0.0	0.0	-7.796		
M3	250.0	.2160		0.0	1.000	.216		Vel = 16.75
	0.0							
	250.00					107.464		K Factor = 24.12
SPA1	250.00	2.469		0.0	25.000	105.643		Qa = 250
to		120.0		0.0	0.0	10.394		
BRA	250.0	.2154		0.0	25.000	5.386		Vel = 16.75
BRA	0.0	6.065	B	10.0	25.500	121.423		
to		120.0		0.0	10.000	1.732		
M2	250.0	.0027		0.0	35.500	.096		Vel = 2.78
M2	0.0	6.065	E	14.0	1.000	123.251		
to		120.0		0.0	14.000	0.0		
M1	250.0	.0027		0.0	15.000	.041		Vel = 2.78

Final Calculations - Hazen-Williams

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	*******	Notes	******
	0.0									
	250.00					123.292		K Factor = 22.52		

Fire & Risk Alliance
1801 W. Warner Ave., Suite 301
Chicago, IL 60613
312-981-8889

Job Name : Third Floor
Drawing :
Location :
Remote Area :
Contract :
Data File : Third Floor.WXF

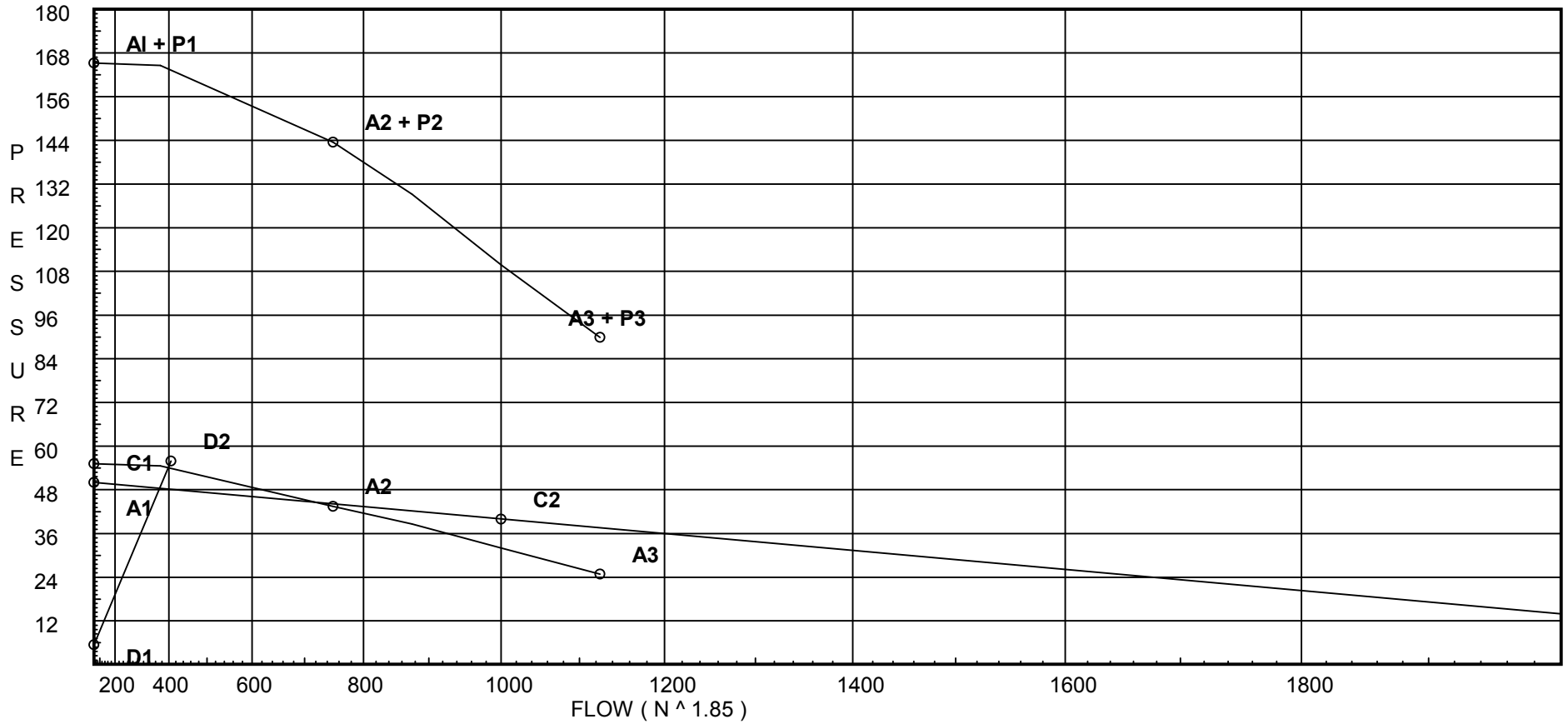
DRAFT

City Water Supply:
- C1 - Static Pressure : 50
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

City Water Adjusted to Pump Inlet for Pf - Elev - Hose Flow
- A1 - Adjusted Static: 55.180
- A2 - Adj Resid : 43.521 @ 750
- A3 - Adj Resid : 24.88 @ 1125

Pump Data:
- P1 - Pump Churn Pressure : 110
- P2 - Pump Rated Pressure : 100
- P2 - Pump Rated Flow : 750
- P3 - Pump Pressure @ Max Flow : 65
- P3 - Pump Max Flow : 1125
- City Residual Flow @ 0 = 2386.83
- City Residual Flow @ 20 = 1810.94
- City Water @ 150% of Pump = 37.57

Demand:
- D1 - Elevation : 5.414
- D2 - System Flow : 406.608
- D2 - System Pressure : 55.900
- Hose (Demand) : _____
- D3 - System Demand : 406.608
- Hose (Adj City) : 100
- Safety Margin : 107.297



Fittings Used Summary

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
B	NFPA 13 Butterfly Valve	0	0	0	0	0	6	7	10	0	12	9	10	12	19	21	0	0	0	0	0
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
F	NFPA 13 45' Elbow	1	1	1	1	2	2	3	3	3	4	5	7	9	11	13	17	19	21	24	28
G	NFPA 13 Gate Valve	0	0	0	0	0	1	1	1	1	2	2	3	4	5	6	7	8	10	11	13
S	NFPA 13 Swing Check	0	0	5	7	9	11	14	16	19	22	27	32	45	55	65					
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121
Zih	Wilkins 450	Fitting generates a Fixed Loss Based on Flow																			

Units Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
S8	12.5	11.2	12.8	na	40.07	.1	189	12.8
S9	12.5	11.2	13.89	na	41.75	.1	213	12.8
M9	12.5		18.49	na				
M8	12.5		18.59	na				
M7	13.5		19.01	na				
M6	13.5		19.93	na				
M5	13.5		20.48	na				
M4	13.5		21.02	na				
M3	13.5		22.52	na				
M2	13.5		22.71	na				
M1	11.75		31.44	na				
TR	11.75		35.91	na				
BR	-30.75		54.88	na				
PO	-30.75		55.9	na				
PI	-30.75		53.83	na				
UG1	-39.75		57.8	na				
UG2	-39.75		58.02	na	100.0			
TEST	0.0		47.16	na				
S7	12.5	11.2	14.7	na	42.94	.1	215	12.8
1	12.5		15.83	na				
S6	12.5	11.2	14.77	na	43.04	.1	222	12.8
S3	12.5	11.2	13.8	na	41.61	.1	190	12.8
S4	12.5	11.2	14.57	na	42.75	.1	198	12.8
S5	12.5	11.2	17.33	na	46.62	.1	238	12.8
S2	12.5	11.2	22.61	na	53.26	.1	197	12.8
S1	12.5	11.2	23.74	na	54.57	.1	304	12.8
M10	12.5		30.07	na				
M11	12.5		30.15	na				
M12	12.5		30.21	na				
M13	12.5		30.29	na				
M14	12.5		30.34	na				
M15	12.5		30.42	na				
M16	12.5		30.64	na				

The maximum velocity is 16.99 and it occurs in the pipe between nodes S1 and M10

Note: zero elevation point for this calculation
is located at third level floor.

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
S8	40.07	1.61	T	8.0	10.720	12.800		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
S9	40.07	.0584		0.0	18.720	1.094		Vel = 6.31
S9	41.75	1.61	T	8.0	13.000	13.894		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
M9	81.82	.2189		0.0	21.000	4.596		Vel = 12.89
M9	85.98	4.026		0.0	10.360	18.490		
to		120.0		0.0	0.0	0.0		
M8	167.8	.0096		0.0	10.360	.099		Vel = 4.23
M8	130.98	4.026	T	20.0	10.740	18.589		
to		120.0		0.0	20.000	-.433		
M7	298.78	.0277		0.0	30.740	.851		Vel = 7.53
M7	0.0	4.026	E	10.0	23.320	19.007		
to		120.0		0.0	10.000	0.0		
M6	298.78	.0277		0.0	33.320	.922		Vel = 7.53
M6	0.0	4.026		0.0	20.000	19.929		
to		120.0		0.0	0.0	0.0		
M5	298.78	.0277		0.0	20.000	.554		Vel = 7.53
M5	0.0	4.026		0.0	19.360	20.483		
to		120.0		0.0	0.0	0.0		
M4	298.78	.0277		0.0	19.360	.536		Vel = 7.53
M4	0.0	4.026	4E	40.0	14.190	21.019		
to		120.0		0.0	40.000	0.0		
M3	298.78	.0277		0.0	54.190	1.501		Vel = 7.53
M3	0.0	4.026		0.0	6.920	22.520		
to		120.0		0.0	0.0	0.0		
M2	298.78	.0276		0.0	6.920	.191		Vel = 7.53
M2	0.0	4.026	11E	110.0	138.040	22.711		
to		120.0	2T	40.0	150.000	.758		
M1	298.78	.0277		0.0	288.040	7.976		Vel = 7.53
M1	107.83	4.026	4E	40.0	51.210	31.445		
to		120.0		0.0	40.000	0.0		
TR	406.61	.0490		0.0	91.210	4.466		Vel = 10.25
TR	0.0	6.065	B	10.0	42.500	35.911		
to		120.0	S	32.0	42.000	18.407		
BR	406.61	.0067		0.0	84.500	.562		Vel = 4.52
BR	0.0	6.065	6E	84.0	34.150	54.880		
to		120.0	S	32.0	119.000	0.0		
PO	406.61	.0067	G	3.0	153.150	1.020		Vel = 4.52
	0.0							
	406.61					55.900		K Factor = 54.38
System Demand Pressure						55.900		
Safety Margin						107.297		
Continuation Pressure						163.197		
Pressure @ Pump Outlet						163.197		
Pressure From Pump Curve						-109.371		
Pressure @ Pump Inlet						53.826		
PI	0.0	6.065	G	3.0	8.000	53.826		
to		120.0		0.0	3.000	3.898		
UG1	406.61	.0066		0.0	11.000	.073		Vel = 4.52

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
UG1	0.0	6.16	2E	40.168	9.000	57.797		
to		140.0		0.0	40.168	0.0		
UG2	406.61	.0046		0.0	49.168	.228		Vel = 4.38
UG2	100.00	6.16	3F	30.126	190.000	58.025		Qa = 100
to		140.0	9E	180.757	215.187	-13.691		* * Fixed Loss = 3.525
TEST	506.61	.0070	G	4.304	405.187	2.824		Vel = 5.45
			Zih	0.0				
	0.0							
	506.61					47.158		K Factor = 73.77
S7	42.94	1.61	T	8.0	9.120	14.697		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
1	42.94	.0664		0.0	17.120	1.137		Vel = 6.77
1	43.04	1.61	T	8.0	3.070	15.834		
to		120.0		0.0	8.000	0.0		
M9	85.98	.2399		0.0	11.070	2.656		Vel = 13.55
	0.0							
	85.98					18.490		K Factor = 20.00
S6	43.04	1.61	E	4.0	11.960	14.770		K Factor = 11.20
to		120.0		0.0	4.000	0.0		
1	43.04	.0667		0.0	15.960	1.064		Vel = 6.78
	0.0							
	43.04					15.834		K Factor = 10.82
S3	41.61	1.61		0.0	12.170	13.805		K Factor = 11.20
to		120.0		0.0	0.0	0.0		
S4	41.61	.0627		0.0	12.170	.763		Vel = 6.56
S4	42.75	1.61	T	8.0	9.360	14.568		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
M8	84.36	.2316		0.0	17.360	4.021		Vel = 13.29
	0.0							
	84.36					18.589		K Factor = 19.57
S5	46.62	1.61	T	8.0	8.330	17.326		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
M8	46.62	.0773		0.0	16.330	1.263		Vel = 7.35
	0.0							
	46.62					18.589		K Factor = 10.81
S2	53.26	1.61		0.0	11.450	22.610		K Factor = 11.20
to		120.0		0.0	0.0	0.0		
S1	53.26	.0989		0.0	11.450	1.132		Vel = 8.39
S1	54.57	1.61	T	8.0	9.360	23.742		K Factor = 11.20
to		120.0		0.0	8.000	0.0		
M10	107.83	.3647		0.0	17.360	6.332		Vel = 16.99
M10	0.0	4.026		0.0	19.000	30.074		
to		120.0		0.0	0.0	0.0		
M11	107.83	.0042		0.0	19.000	.080		Vel = 2.72
M11	0.0	4.026		0.0	12.600	30.154		
to		120.0		0.0	0.0	0.0		
M12	107.83	.0042		0.0	12.600	.053		Vel = 2.72

Final Calculations - Hazen-Williams

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
M12	0.0	4.026		0.0	20.000	30.207		
to		120.0		0.0	0.0	0.0		
M13	107.83	.0042		0.0	20.000	.084		Vel = 2.72
M13	0.0	4.026		0.0	11.400	30.291		
to		120.0		0.0	0.0	0.0		
M14	107.83	.0042		0.0	11.400	.048		Vel = 2.72
M14	0.0	4.026		0.0	19.000	30.339		
to		120.0		0.0	0.0	0.0		
M15	107.83	.0042		0.0	19.000	.079		Vel = 2.72
M15	0.0	4.026		0.0	53.020	30.418		
to		120.0		0.0	0.0	0.0		
M16	107.83	.0042		0.0	53.020	.223		Vel = 2.72
M16	0.0	4.026	T	20.0	43.950	30.641		
to		120.0	5E	50.0	70.000	.325		
M1	107.83	.0042		0.0	113.950	.479		Vel = 2.72
	0.0							
	107.83					31.445		K Factor = 19.23

THIS PAGE INTENTIONALLY LEFT BLANK

Laney College Library & LRC - Building Performance Narrative - 100% DD Progress

June 19th, 2020

Alter
Consulting Engineers

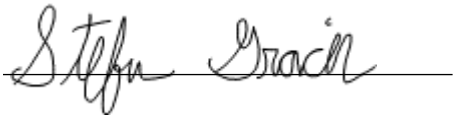
1624 Franklin Street, Suite 1300
Oakland CA, 94612
510.876.2591

Executive Summary

Alter Consulting Engineers completed a 100% design development building performance analysis of Laney College Library & LRC. The activities include recommendations for the design of envelope systems, with a focus on comfort, resiliency, and energy performance. An energy performance benchmarking study was conducted to provide energy targets for the building based on a similar high-performance Library recently designed in the Bay Area.

The building was examined, and an early stage estimate of PV generation was found, which provided the building with an Energy Use Intensity (EUI) target for Zero Net Energy Operation, if only the roof is to be used for the placement of PV panels.

Initial energy model results are developed to estimate the proposed building's EUI, as well as LEED V4 Optimize Energy points, and Title 24 performance, using the current proposed envelope and mechanical systems, as well as a range of lighting power densities in accordance with Title 24 2019 standards. Initial results show the building can achieve 15-20% energy cost savings without solar panels for LEED, and 20-25% Greenhouse Gas Emissions Savings, indicating 6 LEED Optimize Energy Points, as well as 10-15% savings beyond Title 24, 2019.



Stefan Gracik, PE

Principal in Charge, Alter Consulting Engineers

Table of Contents

I. Overview

The following report has been prepared to summarize the 100% detailed design building performance analysis conducted by Alter Consulting Engineers (AlterCE).

Building Description

Laney LRC is an approximately 72,000 GSF 4 story educational building located in Oakland, California. The building includes mostly classrooms and Library spaces. This narrative describes the best path forward for achieving a sustainable and high-performance design, as well as energy benchmarking, Zero Net Energy Goals, and energy and LEED performance. Main sustainable features explored in this narrative include high performance glazing, substantial building shading, and a dual-duct HVAC system which eliminates reheat energy.

Summary of Approach

The Laney LRC's appeal for a building that can produce as much energy on-site as it consumes annually is a challenge that can be met with collaboration, dedication, and attention to detail by all members of the ownership, design, and construction team. Creative thinking about how and when the building will be used, an embrace of creativity, innovation, and collaboration between owners and all members of the project design and construction team, and sustained attention to detail throughout project delivery are all essential.

The building will use electricity directly in the space conditioning systems. The amount of energy used by these systems may be minimized through a high-performance building envelope, low power consuming systems inside the building, and a mechanical system responsive to the resources of the site. The energy used by the building may be offset by solar PV panels mounted on the building's roofs.

In the heating season, the most effective strategies will be to focus on optimizing the building envelope and maximizing the efficiency of mechanical systems for minimal ventilation heating.

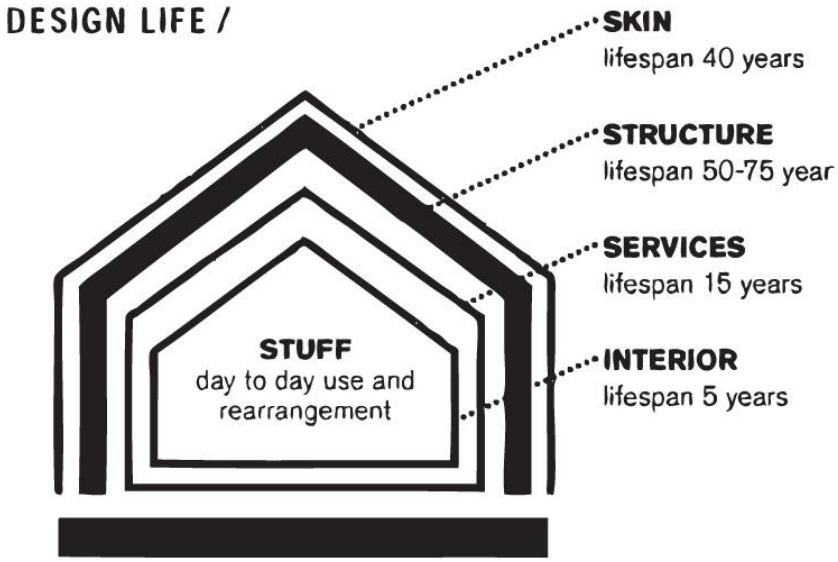
In the cooling season, however, there is wonderful opportunity to use the climatic resources found on site as an integral part of the space conditioning strategies. The biggest resources the Laney LRC has in this respect are wind and moderate temperatures. The design challenge is to find a way to use these resources. The wind can be used for natural ventilation nearly year-round, reducing the energy of the mechanical system. Additionally, an airside economizer can make use of the mild climate to reduce energy consumption in spaces that do not have access to natural ventilation.

II. Building Sustainability

Total building heating and cooling energy use is not only a function of the source heat efficiency, but also in how quickly heat is lost or absorbed to the atmosphere. Highly

insulated roof, walls, and windows all help to lower this heating migration and reduce the requirements for an HVAC system to maintain thermal comfort.

Having a façade tuned to utilize a simple HVAC system means fewer controls, fewer items to break, often smaller systems and even shorter floor to floor heights with less space dedicated to HVAC systems. The goal being, how can a building design transfer complexity and cost from the short-life HVAC (15 to 20 years) to the long-life building façade and structure (40 to 75 years).



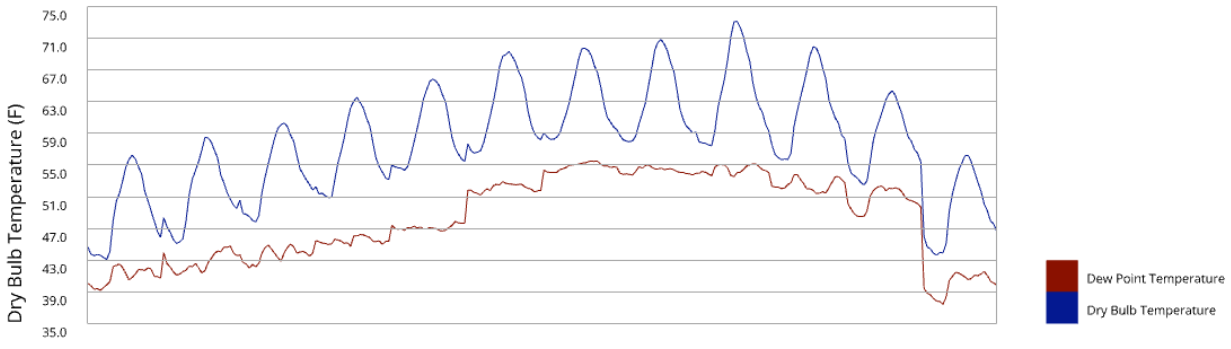
The summary of the goal of envelope optimization is to reduce the heat losses in winter and reduce the heat gains during summer. The major components in terms of heat gains and losses can be summed up by the following systems:

- Walls
    - Heat loss from temperature difference (winter)
- Roof
    - Heat loss from temperature difference (winter)
    - Heat gain from solar radiation (summer)
- Slab
    - Heat loss due to temperature difference (winter)
        - Typically, minor, but much greater in heated slab projects
- Infiltration
    - Heat loss due to temperature difference (winter)

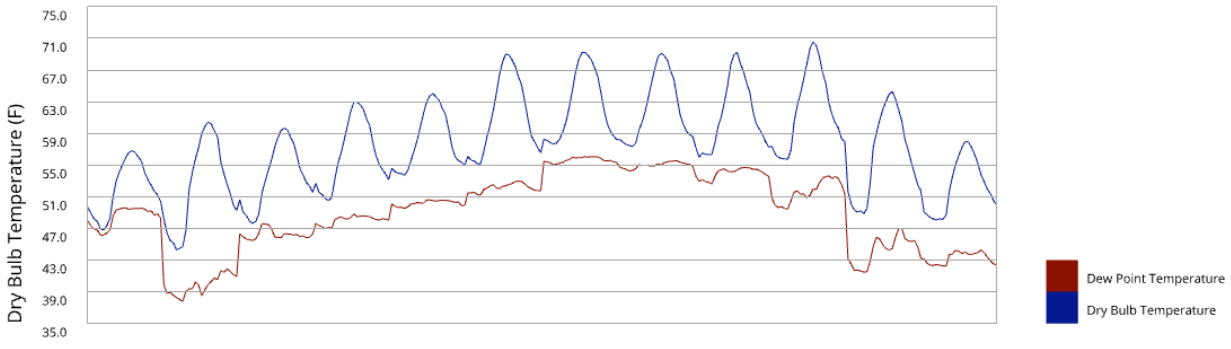
- Windows
    - Heat **loss** due to temperature difference (winter)
    - Heat **gain** due to solar radiation (summer)

Local Weather Analysis

A weather analysis was completed. Since the climate is generally warming, it is standard AlterCE practice to consider the most recent actual meteorological year (AMY) in addition to typical year (TMY) weather files. The latest average weather data for Oakland shows that the typical year weather file is fairly close to the 2018 data (the latest available). The typical year has a warmer summer than what was recorded in 2018, while winter is fairly close. For these reasons, the team will use the typical year file to maintain conservatism in how warm of temperatures are likely to be experienced by the building. It is possible to shift the typical weather data to estimate warming due to global climate change, and this analysis may be conducted if it is deemed of interest to Laney/Peralta.

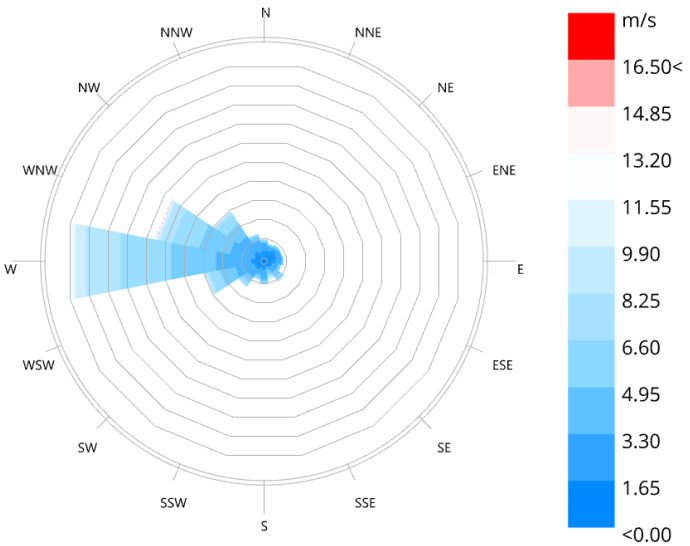


Oakland AP - Typ12 Weather Data



Oakland AP - 2018 Weather Data

The wind was also analyzed, from the Oakland airport. Wind from the west is the dominant feature and should be considered when designing glazing and mechanical systems that will interact with the outdoor wind.

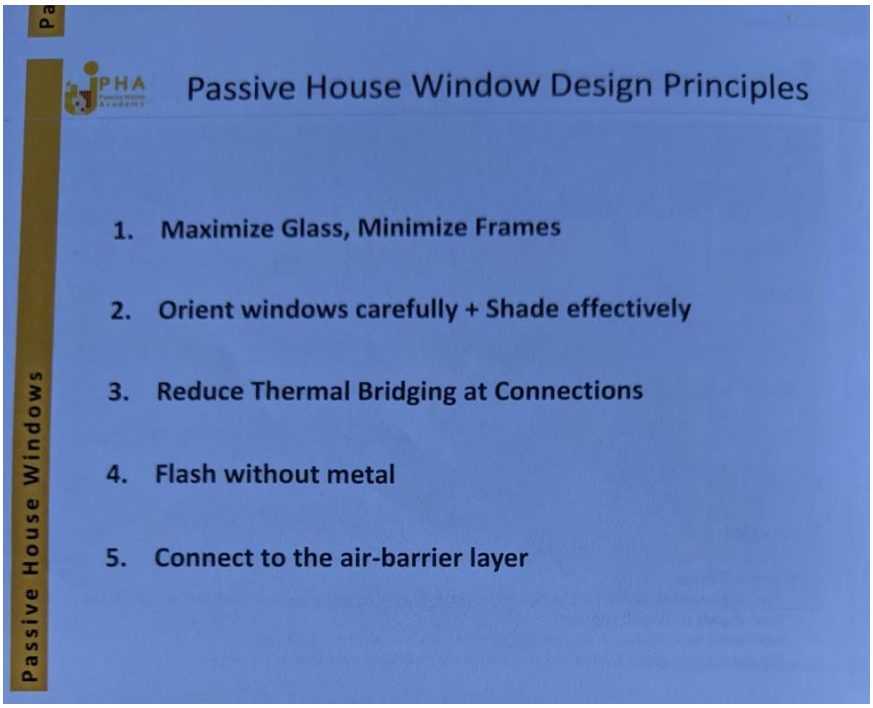


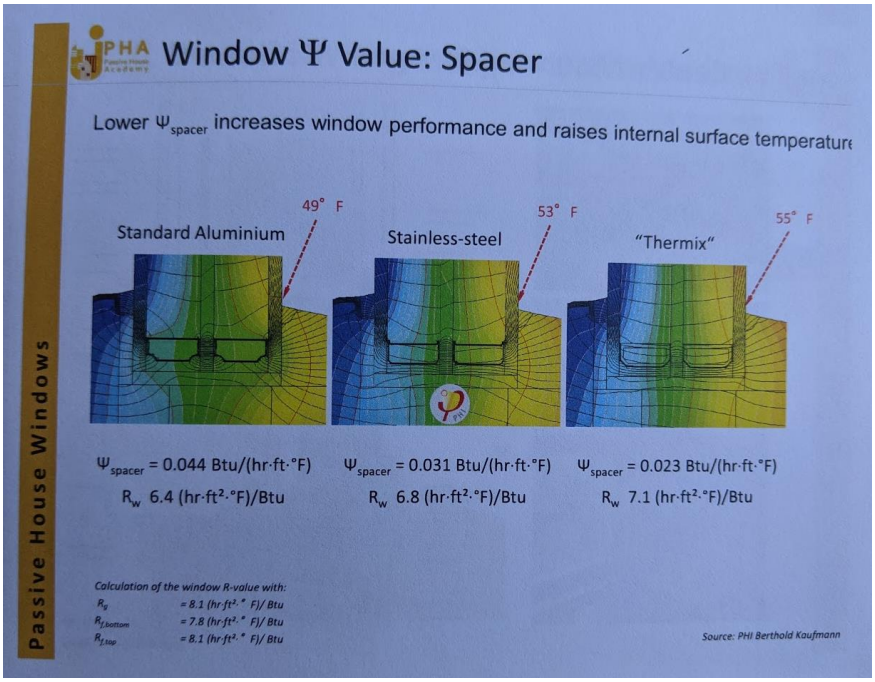
Wind-Rose
CA_OAKLAND-METRO-AP_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 6.92% of the time = 606 hours.
Each closed polyline shows frequency of 2.8%. = 244 hours.

Envelope Performance

Optimizing window to wall ratio, to ensure enough glazing is provided for good daylighting performance while limiting impact on heating and cooling loads, is essential for any high-performance building.

Good glass can insulate to the level near R-3. When compared to an R-20 wall, significant glazing in any given area of wall or roof severely hampers its thermal performance. Over-glazing can create local thermal comfort problems due to drafts on cold days and radiant hot spots on hot days. The following examples from Passive House Institute illustrate how to design windows to minimize thermal bridging, maximizing performance.





The use of low solar gain glazing units can reduce the solar energy entering the building by 70% while still allowing the full spectrum of visible light to benefit the occupants. External shading can be extremely useful in reducing solar gains. An automated shading system which lowers to block direct sunlight but raises automatically to allow diffuse light is a near-optimal system, reducing cooling while maximizing daylighting. An example shown below is from Passive House Institute.

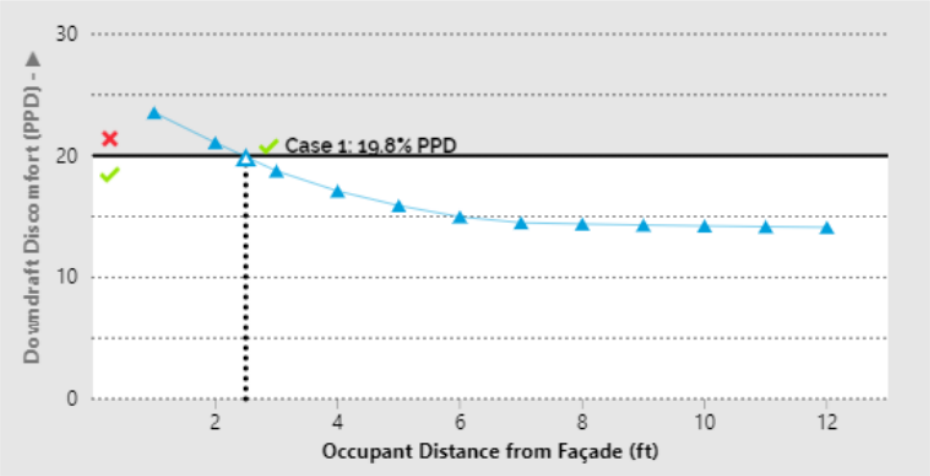

Passive House Windows
External Roller Blinds – PH Sports Hall
Blinds retracted, maximising solar gains
Blinds extended, preventing overheating
Internal view, blinds retracted
© Passive House Academy

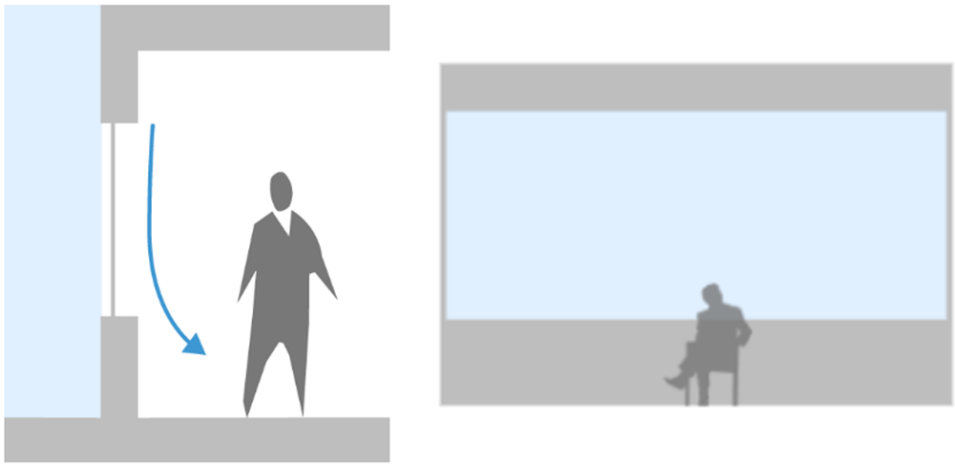
Designing for Thermal Comfort

Windows, being the least insulative part of the building envelope are most subject to thermal comfort issues.

Draft discomfort - Cold convective air currents, formed by warm room air hitting the cold window surface, create discomfort at the occupant's feet and ankles. The strength of these currents depends on the height of the windowpane, as well as the interior temperature of the glass. Draft discomfort is quantified by an estimate of percentage of people dissatisfied with the thermal environment when standing at a specified distance from a window.

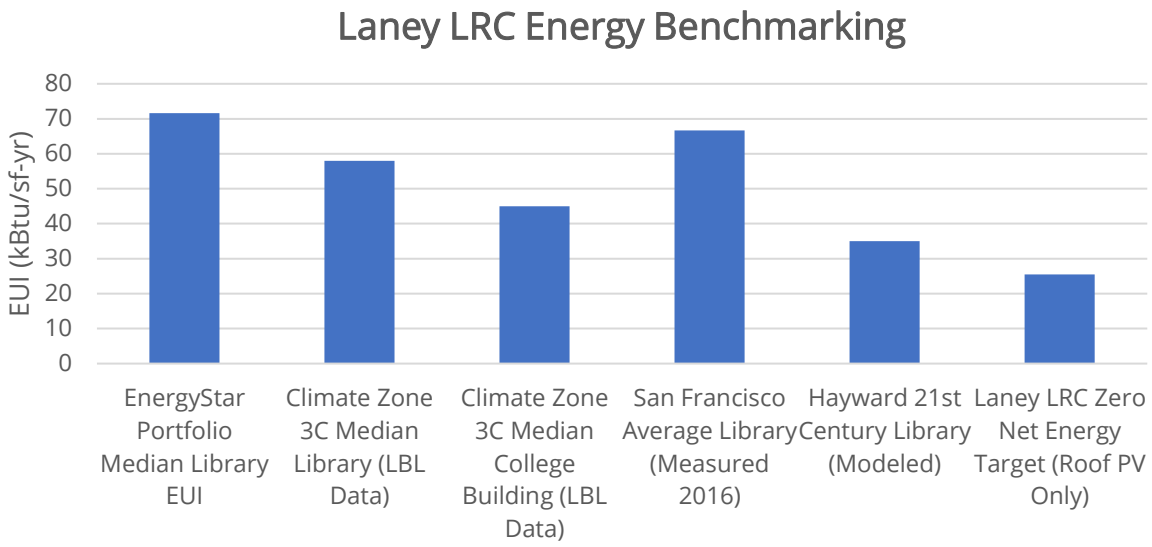
Preliminary analysis suggests targeting 0.35 U-factor to meet ASHRAE Std 55 draft discomfort PPD target of 20% at a distance of 2.5' from the window – Note that a radiant heated floor will assist in reducing the draft effect. Draft increases as the window height increases, so double and triple height spaces would benefit from even more insulated windows.





Building Energy Benchmarking

To establish energy performance goals for the project, an energy benchmarking study was conducted, to compare the Laney LRC to similar buildings around the country, and in the region. Of special interest is the Hayward 21st Century Library, which was recently designed, and is currently under construction. It is recommended that this building be used for energy comparison, as it was design to achieve Zero Net Energy operation. Additionally, a Zero Net Energy performance goal is included, which shows the energy requirements for the building if the roof is aggressively covered in solar panels.



III. Energy Model Results

Zero Net Energy Target

Area takeoffs of the Laney LRC were conducted to estimate the maximum amount of solar panels that could ever be installed on the roof. An initial assumption is that 80% of the level 4 roof area could be covered in PV. This may be an overestimate given the shape of the roof, but provides an initial bound to the maximum energy generation possible. Additional assumptions include the following:

- 21,400 sf available roof space
- 17,000 sf panel area (assumes 80% coverage)
- 300 kW system installed (high efficiency panels @18 w/sf)
- 1700 kWh/kW generation (5 degree tilt, high efficiency panels)
- 523,000 kWh/yr generation
- 25 EUI offset (70,000 sf building)

PV area measured is represented by green hash area (before 20% reduction for spacing is taken)

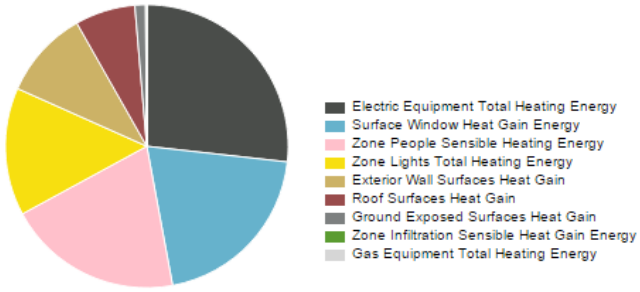
Energy Model Results

Envelope Performance

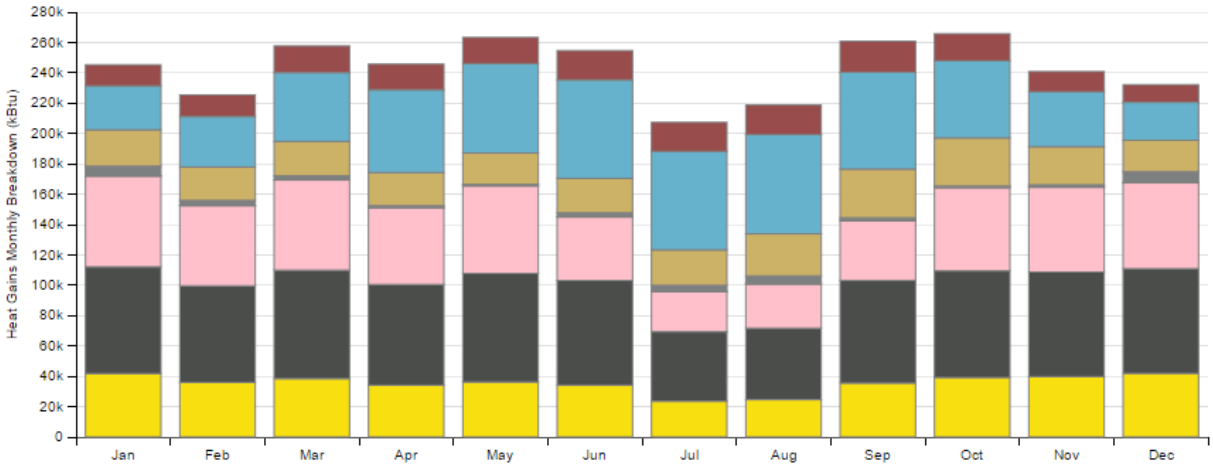
A model of the building massing was used to estimate the greatest contributors to heat gains/losses in the building throughout the year. This illustrates where the project team should strategize efforts to improve building energy performance through the facade.

The pie chart below displays the annual breakdown, and the bar chart displaying the monthly breakdown of heat gains occurring in the model. The largest source of heat gains is from the interior electrical equipment, which is estimated based on the space type distribution. While these loads can be reduced with careful management of installed loads and plug load controls, it takes significant occupant cooperation to achieve reductions. The next largest loads are the gains through windows (which includes direct solar gains and conduction). The building already features a substantial shading design, and high-performance glazing, which minimizes heat gains. While a lower window-wall ratio would reduce these gains, the current design has relatively good solar control, given that the heat gains are approximately equal in magnitude to the gains from occupants throughout the year, and less than the gains from plug loads. If the shading design was reduced, or lower performance windows were selected, this study should be revisited.

Heat Gains Annual Breakdown (kBtu) - view table



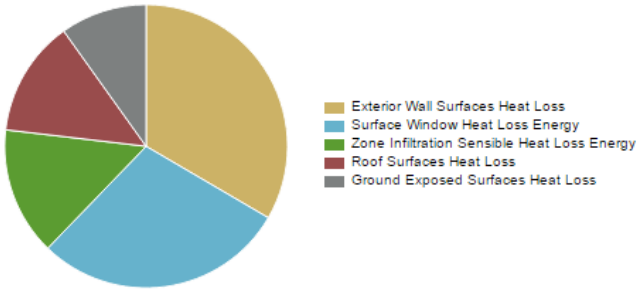
Heat Gains Monthly Breakdown (kBtu) - view table



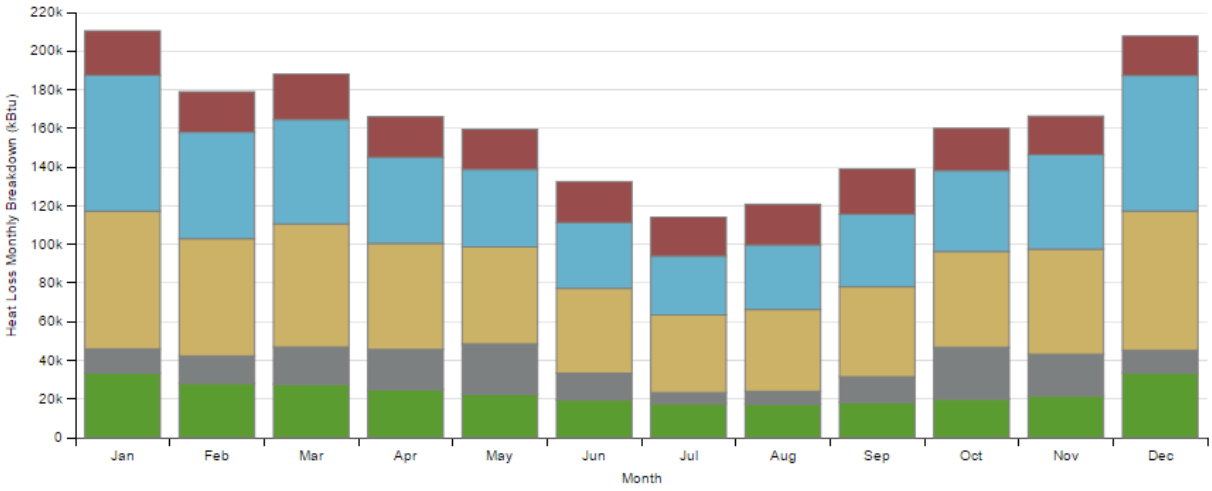
The following charts show the building heat losses throughout the year, the pie chart displaying the annual breakdown, and the bar chart displaying the monthly breakdown of heat losses occurring in the model.

The largest source of heat loss in the model is heat loss via conduction through the building exterior walls. This is likely due to the large amount of uninsulated concrete walls on the project. Typically, buildings with larger window-wall-ratios lose heat mostly through glazing, but the high-performance glazing selection actually achieves a higher R-value than the uninsulated concrete walls (though there is a thermal mass benefit as well), resulting in a higher heat loss through walls. The thermal mass of the walls may exaggerate the amount of heat gains and losses through the walls, since the walls are constantly absorbing and releasing lots of heat as the building cycles through its setback and setpoint. For this reason, higher R-value walls should only be considered if tested alongside another efficiency strategy to compare the energy savings potential of both options.

Heat Loss Annual Breakdown (kBtu) - view table

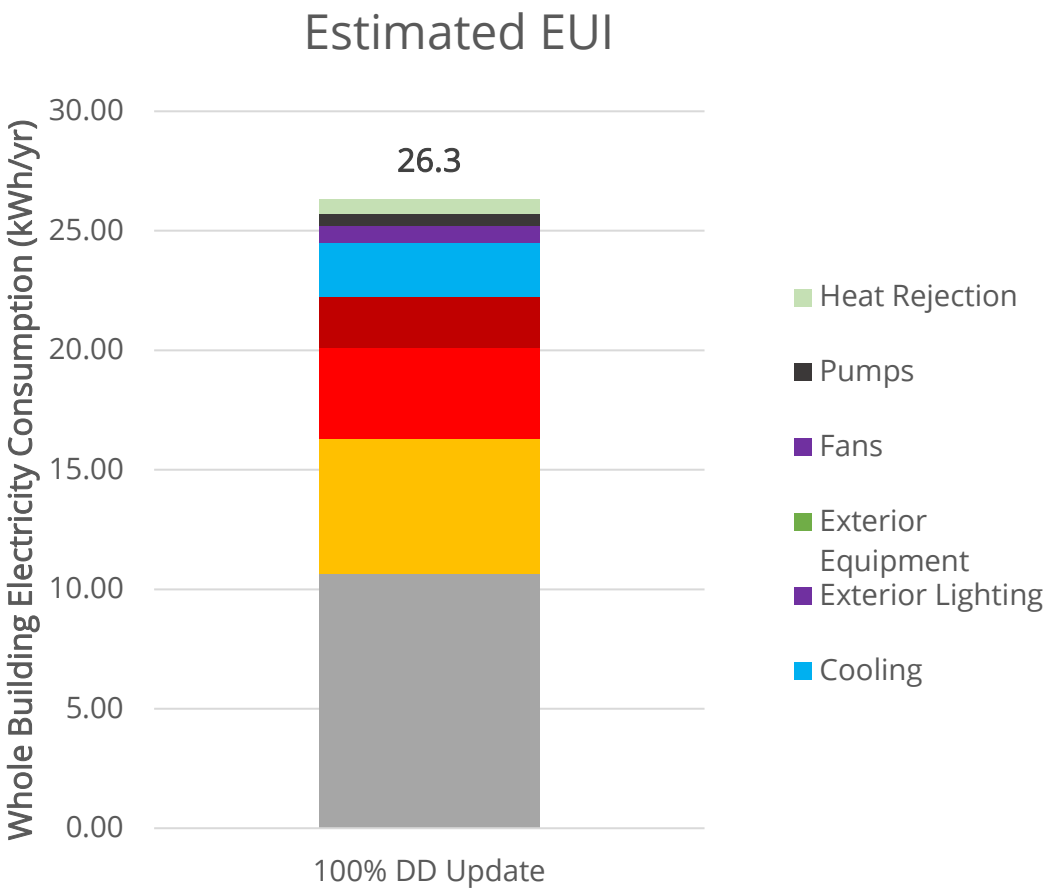


Heat Loss Monthly Breakdown (kBtu) - view table



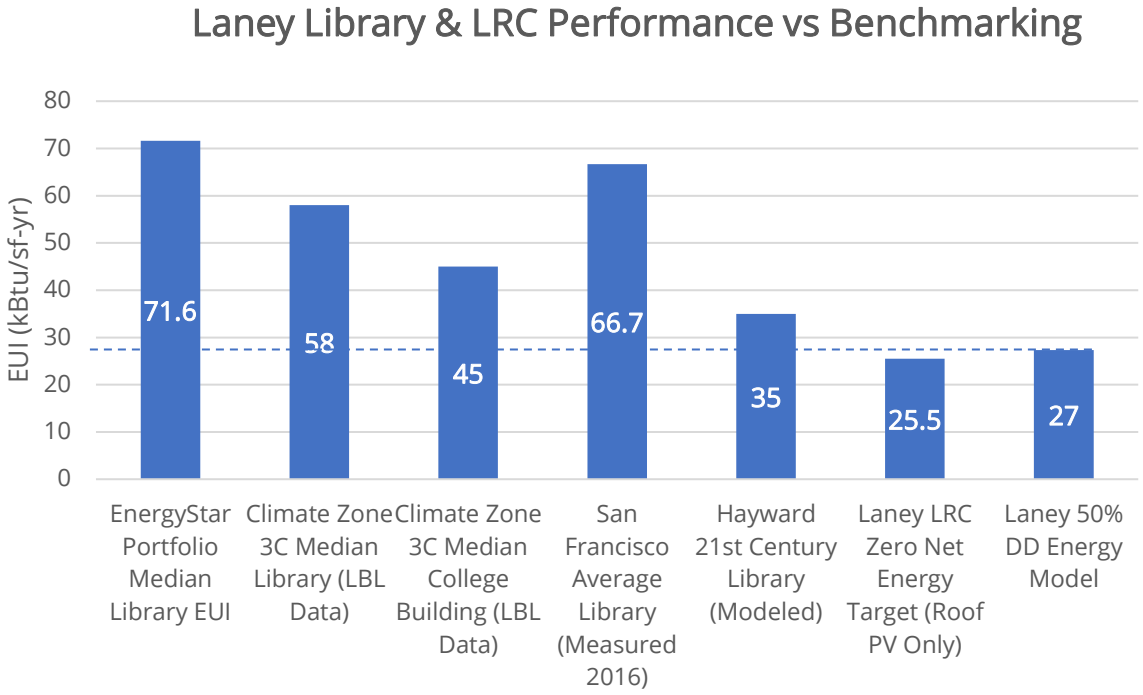
Energy Performance Results

The initial energy consumption results of the model are shown below.

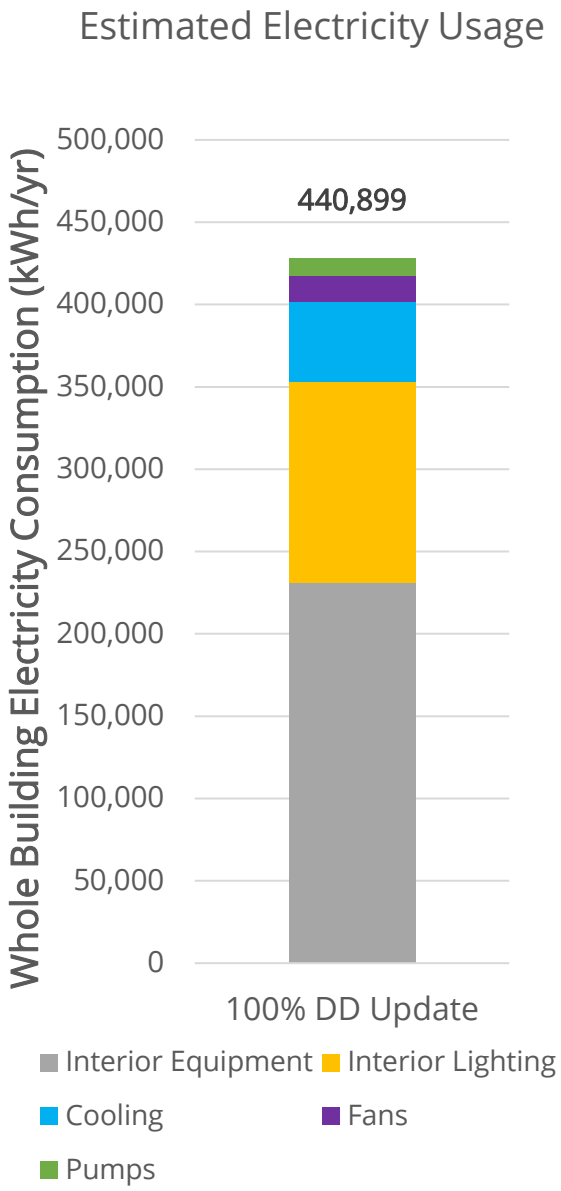


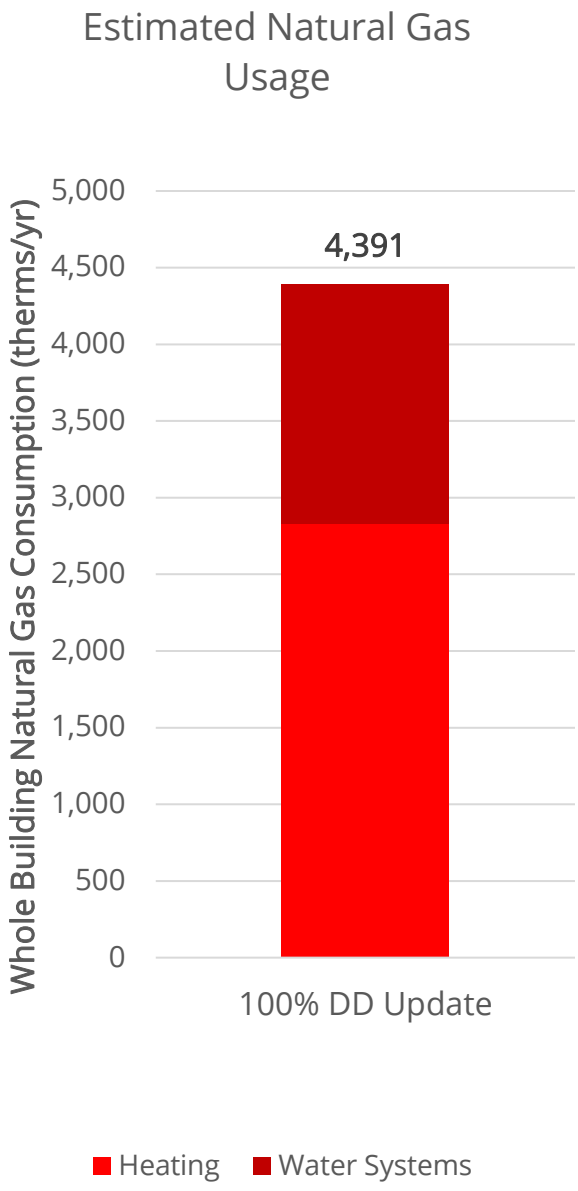
The EUI shows that the major contributors to building energy consumption are the interior equipment (plug loads) and interior lighting categories. The interior equipment is an estimate based on ASHRAE 90.1 assumptions of the space types of the building. The lighting is based on Title 24 2019 lighting power density assumptions per space type – which feedback from lighting designers suggests it will be difficult to achieve savings against. The heating and cooling loads are low, a result of the high-performance glazing and significant solar shading in the envelope, and the airside economizer and lack of reheat in the mechanical design.

The chart below shows the building's energy performance compared the building benchmarking targets established previously:

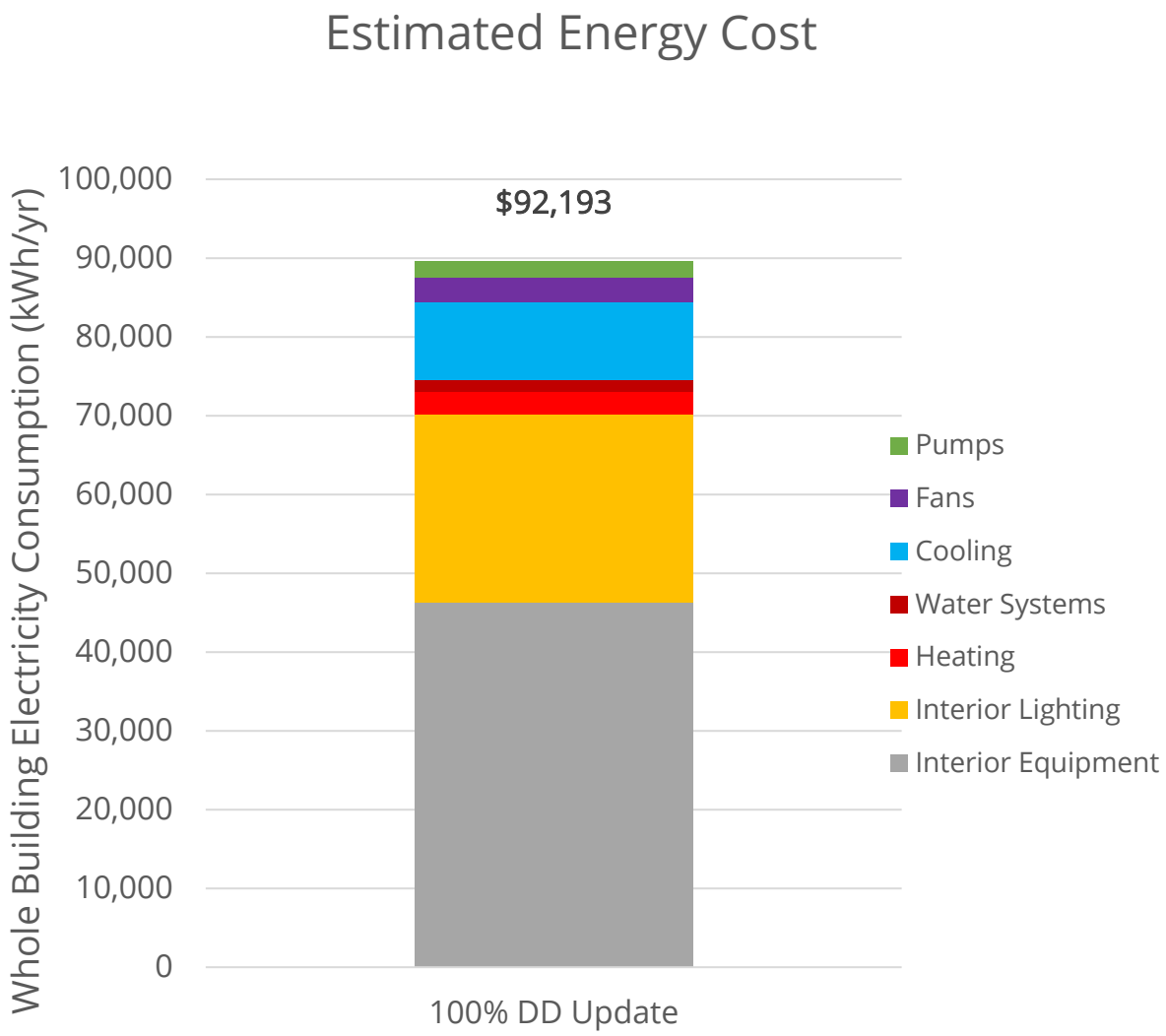


The building's estimated electricity and gas consumption is shown in the charts below.





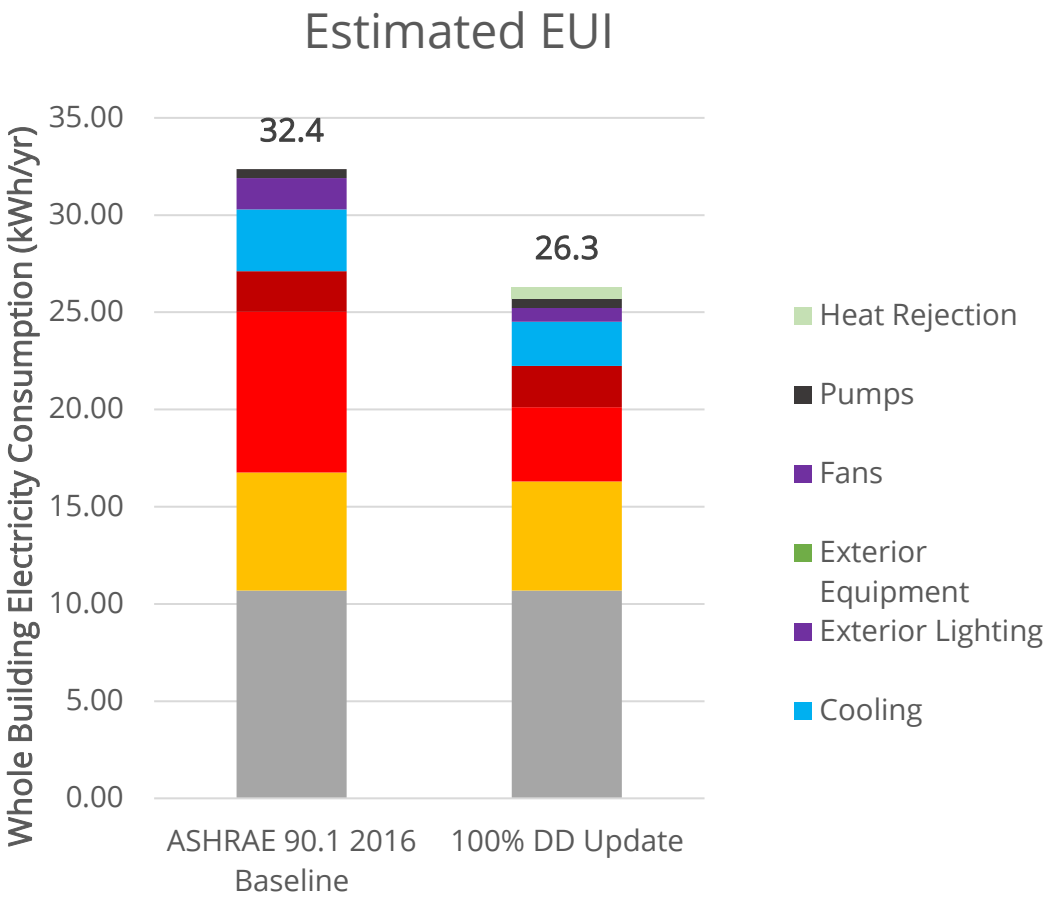
The buildings estimated utility cost is estimated in the following chart – assuming EIA average utility rates in California of $0.189/kWh and $0.89/therm.

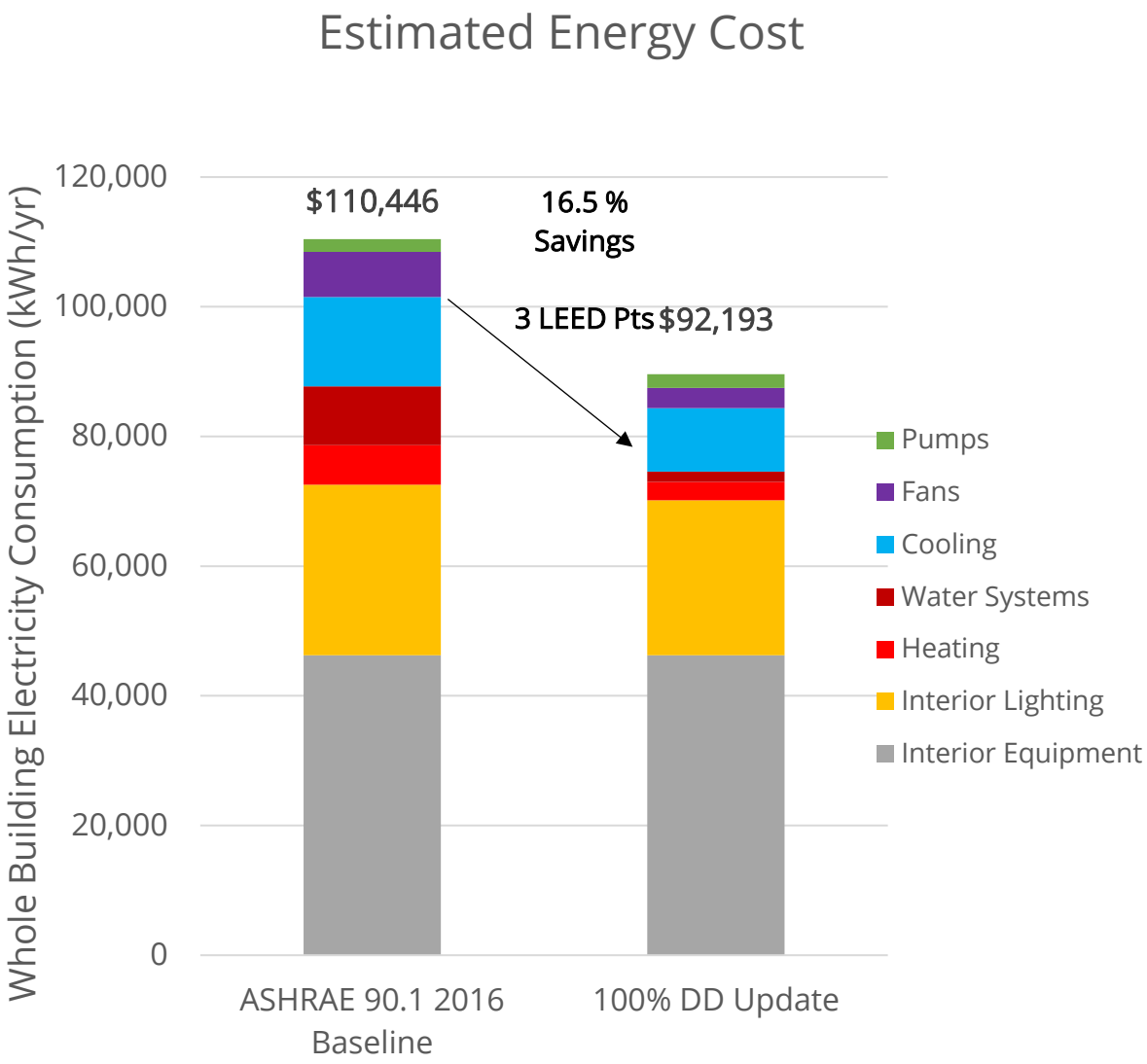


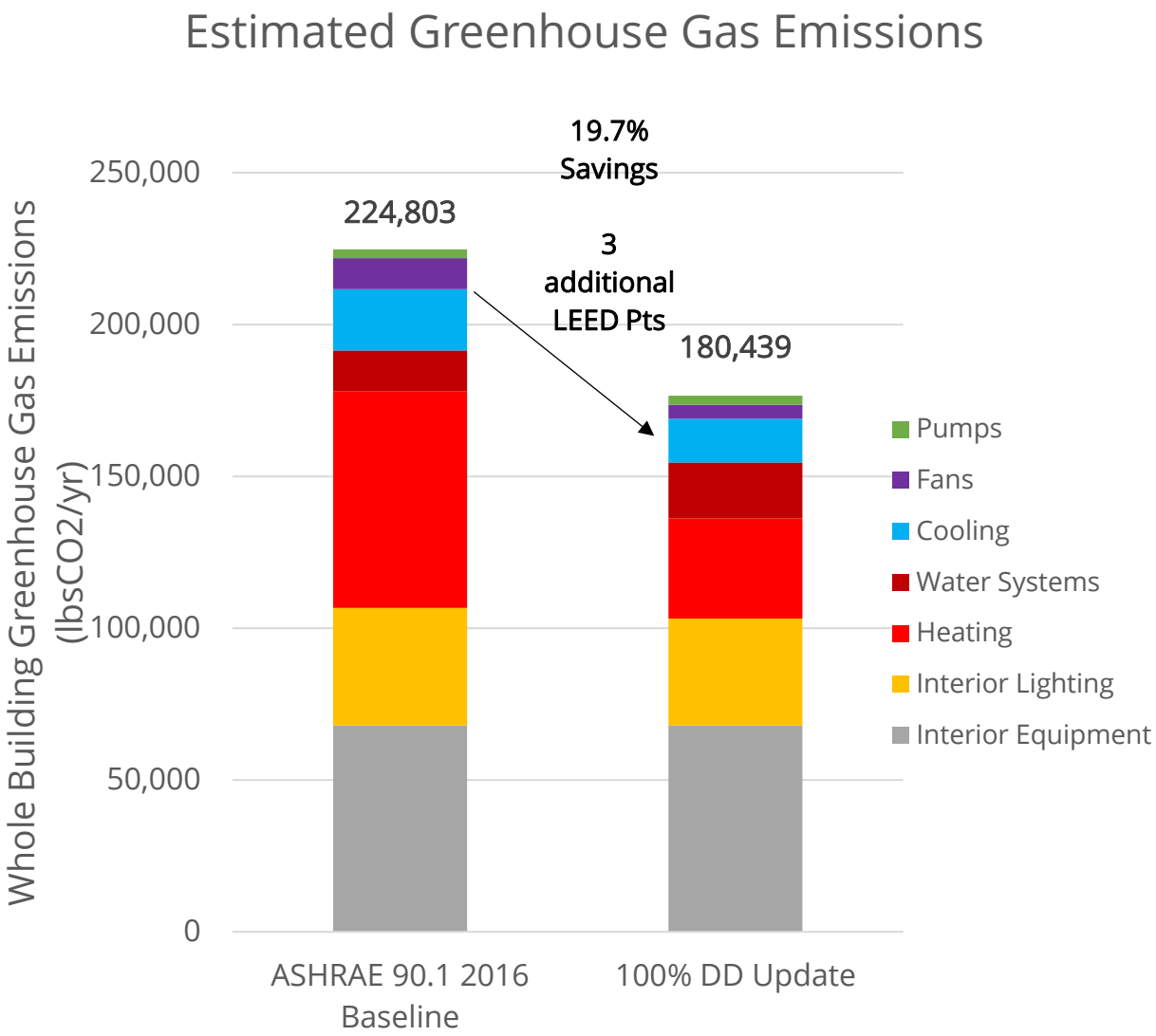
LEED V4.1 Energy Performance

The Optimize Energy credit for LEED offers the potential for more points than any other credit, up to 20. For the 4.1 version of LEED, the USGBC has significantly increased the stringency of the credit by moving to the ASHRAE 90.1 2016 baseline. 10 credits are awarded based on the projects energy cost savings percentage compared to a baseline energy model that is built to ASHRAE Standard 90.1 2016 (for LEED V4.1, versus 2010 for LEED V4). The credit now also considers greenhouse gas emissions and awards up to 10 pionts for greenhouse gas emissions reductions. The below charts show the proposed designs energy performance compared with the ASHRAE Baseline model, for both site energy consumption (EUI), and energy cost (which determines LEED points). Energy cost is based on average California utility rates, as determined by the EIA. The project is currently estimated to achieve 20% energy cost savings compared to the baseline, which corresponds with 6 energy points.

Since natural gas has a high emissions factor, the building does well saving greenhouse gas emissions compared to the baseline due to the HVAC system saving considerable natural gas usage. Unfortunately, since natural gas is a cheap fuel in comparison to electricity, this means the building does not see as good of energy cost savings. The greenhouse gas emissions calculation uses PG&E assumptions for electricity generation – equivalent to 294 lbs-CO2/kWh, and 11.7 lbs-CO2/therm for natural gas.

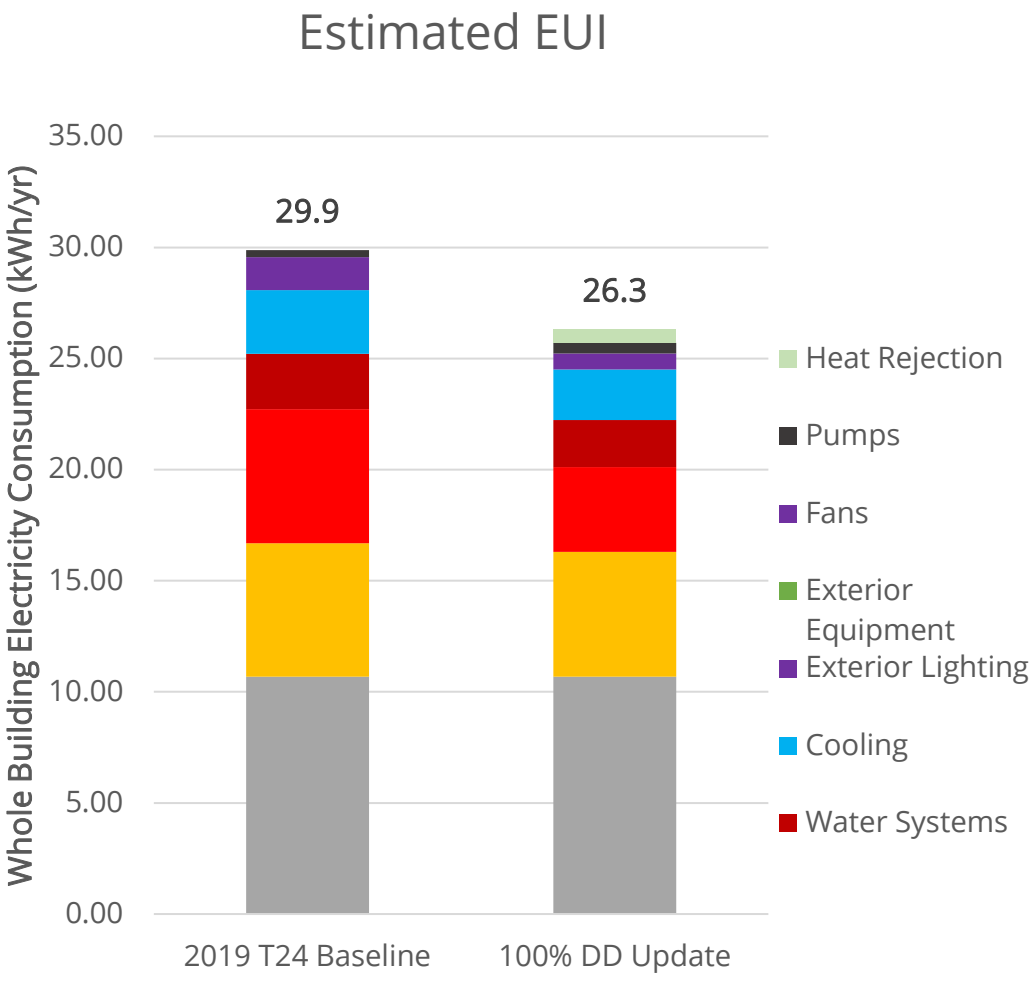


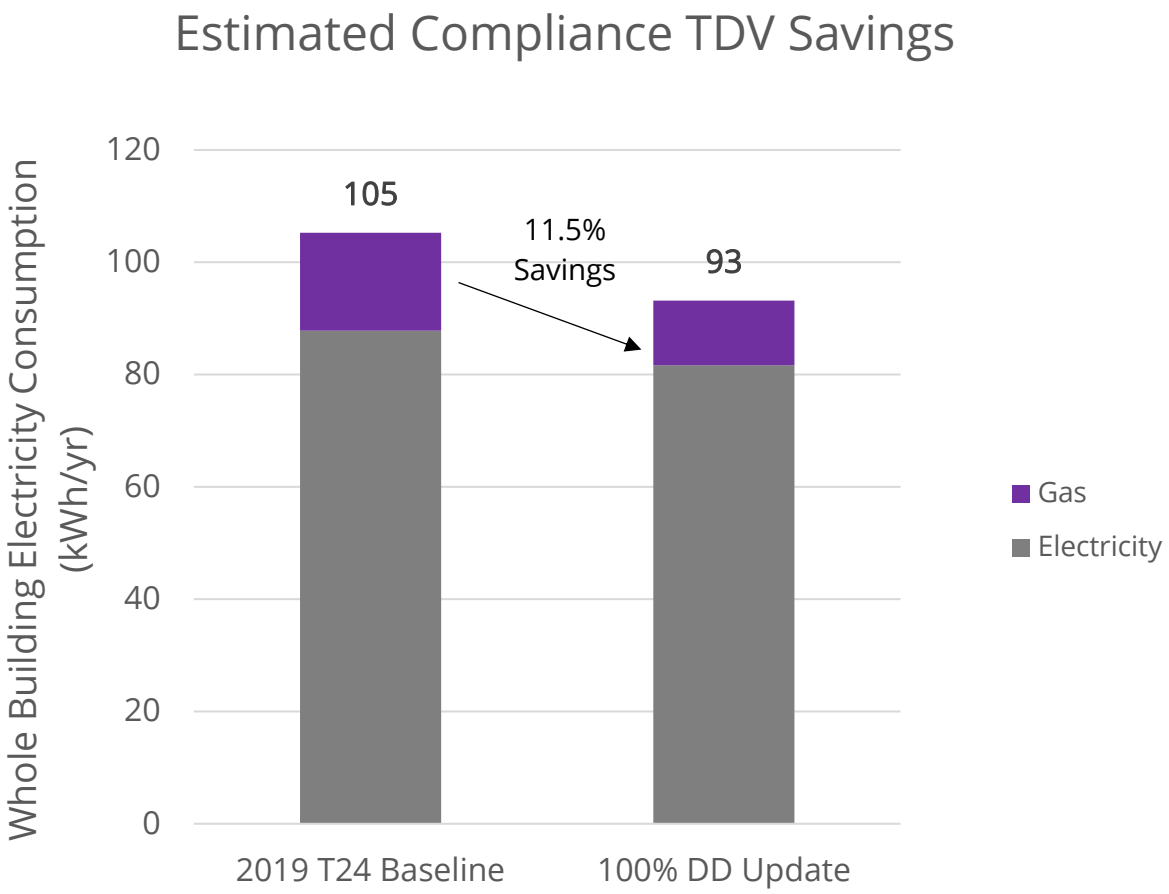

Estimated Energy Cost
Whole Building Electricity Consumption (kWh/yr)
120,000
100,000
80,000
60,000
40,000
20,000
0
$110,446
16.5 %
Savings
3 LEED Pts
$92,193
ASHRAE 90.1 2016
Baseline
100% DD Update
Pumps
Fans
Cooling
Water Systems
Heating
Interior Lighting
Interior Equipment



Title 24 2019 Performance

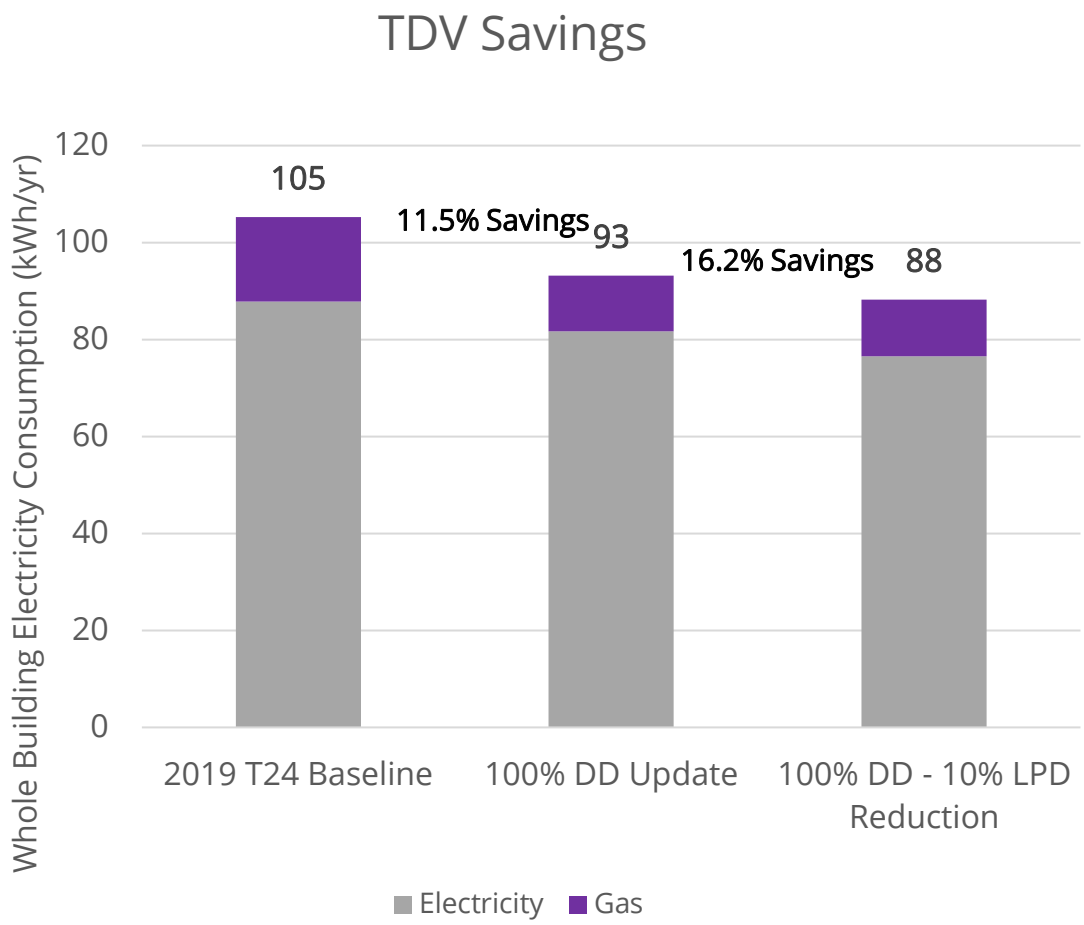
The project has a goal of 15% better than Title 24 2019 performance. Title 24 performance is estimated using TDV – which is California Time Dependent Valuation – which attempts to capture the increased energy cost during peak periods. Title 24, like ASHRAE 90.1, requires an energy modeling comparison to estimate performance compared to a building built to code minimum. Title 24 is more stringent than ASHRAE 90.1 2010, featuring much lower lighting power densities, and high-performance windows frames. In fact, it's assumed that the design team will struggle to claim any lighting savings compared to Title 24 2019. For these reasons, estimated Title 24 performance is much less than the LEED performance. The charts below summarize the energy performance, and estimate the project will not meet it's 15% better than Title 24 goal. Current results show 10% savings compared to Title 24 2019.


Estimated EUI
Whole Building Electricity Consumption (kWh/yr)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
29.9
26.3
2019 T24 Baseline
100% DD Update
Heat Rejection
Pumps
Fans
Exterior Equipment
Exterior Lighting
Cooling
Water Systems



Lighting Power Density Parametrics

The proposed model assumes that the building will meet Title 24 2019 lighting power densities – as feedback from lighting designers is that it is difficult to improve upon this margin. This results in no lighting energy savings when compared against the Title 24 baseline. For the purposes of setting lighting targets however, it was examined what the Title 24 Energy performance would be if the lighting design could beat the baseline Title 24 2019 lighting power densities by 10 or 20%. The results show that the project can potentially meet it's 15% savings compared to Title 24 goal if the lighting power is reduced by 10% compared to Title 24 requirements, or an overall LPD of 0.64 W/sf.



IV. Energy Recommendations

Based on the current energy modeling, AlterCE maintaining the high-performance glazing and substantial shading present in the design in order to maintain the projects energy performance goals. The results show that the envelope features are balanced in that there are no obvious areas with lots of room for improvement, with the possible exception of the uninsulated concrete walls.

The interior lighting design shows the most potential for additional energy savings, so we recommend additional coordination with the lighting design team to understand what lighting power reduction targets are feasible compared to Title 24 2019

The building also benefits from the assumed retrofitted central plant at the college. It's imperative for energy performance that the central plant retrofit coincide with this building design, and that the central plant is designed as efficiently as possible so that proper energy savings estimates can be established.

Appendix: Energy Model Inputs

Energy Model Geometry

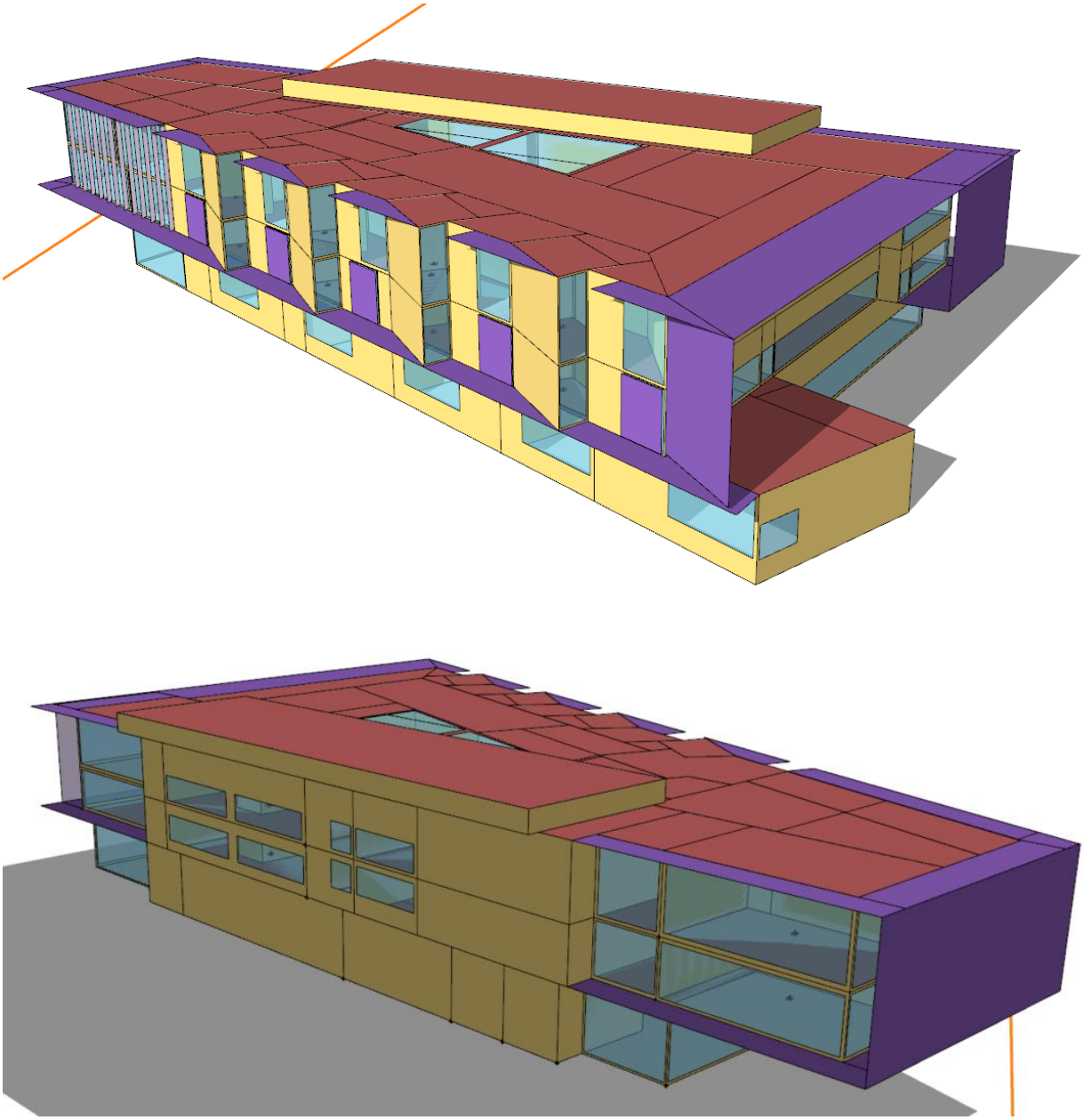


Figure 1: Energy Model Geometry (Transmissivity properties are used to properly account for shading slats)

Energy Model Detailed Inputs

COMMON MODEL INPUTS

Parameter	Input
Project / Building	Laney College Library & LRC
Occupancy	School Library and Classroom Building
Location	Oakland, CA
Weather File	Oakland, CA
Climate Zone	ASHRAE 3C, CEC 3
Utility Rates	$/kWh $/therm
Carbon Emissions Rates	Lbs CO2e/MWH
Building Footprint	72,000 sf

BASELINE, PROPOSED MODEL INPUTS COMPARISON

Parameter	Description	Units	Value
Architectural			
Walls [Concrete]	16 inch Solid Concrete	R-value	1
Walls [Framed]	2x6 metal stud w/ 1 in Exterior CI	R-value	10
Roof	6 inches insulation above metal deck	R-value	30
Slab on Grade	Slab on Grade	F-Factor	0.73
Infiltration Rate	standard ASHRAE assumption	cfm/ft2 ext	0.048
Glazing Center of Glass	Solar Ban 90 w/ Argon fill	SHGC	0.24
Glazing Assembly	Kawneer 1600 UT	U-value	0.34
Window-to-Wall Ratio (WWR) - Opt A	N 40 E 72 S 35 W 74	%	55
Shading Devices	as-designed		

Parameter	Description	Units	Value
Mechanical			
Distribution System			
Air Type System			
System Description	Built up VAV w/ Baseboard Hot Water Heating (Approximates no reheat in dual duct VAV)		
Total Static Pressure		in	4.5
Fan Min Turn Down	variable	%	
Ventilation Airflow	based on space types	cfm	
Demand Control Ventilation	yes		
Airside Economizer	yes		
Airside Heat Recovery	No		
Supply Air Temperature	Linearly varying	F	55 to 60
Supply Air Contro	Warmest Air Reset	F	70 to 55
Central System			
Primary System			
Heating System Description	Natural Gas Boiler		
Cooling System Description	Water Cooled Chiller		
Cooling Efficiency	assume new code minimum chiller	6.0 kW/ton	
Heating Efficiency	assume new code minimum boiler	80%	
CHW Supply Temperature		F	44

CHW Control	N/A		
Waterside Economizer	none		
HW Supply Temperature		F	153
HW Control	constant		
CHW Pump Control	Variable		
CHW Pump Power	head pressure	ft H20	50
HW Pump Control	Variable		
HW Pump Power	head pressure	ft H20	40
Domestic Hot Water			
System Description	Natural Gas Boiler		
DHW System Efficiency	Thermal efficiency	%	95
DHW System Peak Flow Rate		GPM	3
Parameter	**Current Design**		
Utility			
Electricity	EIA Average CA Rates	$/kWh	0.189
Gas	EIA Average CA Rates	$/therm	0.89

Space Area		
Space Type	Name in Model (ASHRAE)	Title 24 Lighting Spacetype
Café Seating	Office MediumOffice - Dining	Dining Area - Cafeteria/Fast Food
Storage	Office MediumOffice - Storage	Commercial/Industrial Storage - Warehouse
Study Room/Conference	Office SmallOffice - Conference	Convention, Conference, Multipurpose and Meeting Area
Classroom	SecondarySchool Classroom - 90.1-2013	Classroom, Lecture, Training, Vocational Area
IT Workrooms	SecondarySchool ComputerRoom - 90.1-2013	Electrical, Mechanical, Telephone Rooms
Corridor/Circulation/Stairs	SecondarySchool Corridor-90.1 2013	Corridor Area
Library Reading/Stacks/Computers	SecondarySchool Library-90.1-2013	Library - Reading Area
Lobby	SecondarySchool Lobby-90.1-2013	Main Entry Lobby
Mechanical, Electrical	SecondarySchool Mechanical-90.1-2013	Electrical, Mechanical, Telephone Rooms
Office	SecondarySchool Office-90.1-2013	Office < 250 square feet
Restroom	SecondarySchool Restroom-90.1-2013	Restrooms

Space Area	Internal Loads			
Space Type	Area in Model [SF]	Occupancy [Per 1000 sf]	Lighting (T24 2019) [W/SF]	Plug Load [W/SF]
Café Seating	748	10	0.4	1
Storage	514	0	0.6	0
Study Room/Conference	6,334	50	0.85	1
Classroom	11,965	35	0.7	0.93
IT Workrooms	1,902	35	0.4	1.86
Corridor/Circulation/Stairs	14,549	0	0.6	0.37
Library Reading/Stacks/Computers	32,075	10	0.8	0.9
Lobby	2,477	0	0.85	0.37
Mechanical, Electrical	1,256	0	0.4	0.37
Office	1,627	5	0.7	1
Restroom	395	0	0.65	0.37
Total	**73,842**	**15.4**	**0.72**	**0.81**

Atrium Smoke Control Report

Laney Library & Learning Resource Center
900 Fallon Street, Oakland, CA

Prepared for:

Noll & Tam Architects
729 Heinz Avenue
Berkeley, CA 94710

Prepared by:

Fire & Risk Alliance, LLC
2551 San Ramon Valley Blvd., Suite 207
San Ramon, CA 94583

Revision 0
August 23, 2020

TABLE OF CONTENTS

RECORD OF REVISIONS

REVISION	DATE	DESCRIPTION
0	August 23, 2020	Initial Release

1.0 INTRODUCTION

Fire & Risk Alliance has been retained by Noll & Tam Architects (client) to conduct a performance-based design analysis for the atrium smoke control system in the new Laney Library & Learning Resource Center located at 900 Fallon Street in Oakland, California.

Laney Library & Learning Resource Center is located in the Peralta Community College District. The building is 3 stories in height and includes classrooms, reading areas and offices. An atrium is located at the center of the building. On Levels 1 and 2, the atrium opens to the adjacent floor spaces. On Level 3, the floor opening is enclosed by glass walls and closely spaced sprinklers, which provide the equivalent 1-hour rated smoke partition per Section 404.6 Exception 1of the 2019 California Building Code (CBC). The atrium will be provided with an automatic smoke control system designed in compliance with Section 404.5 and Section 909 of the CBC.

The applicable method of smoke control for the Laney Library atrium is the exhaust method. According to CBC Sections 909.4.6 and 909.8.1, a smoke control system designed in accordance with the exhaust method shall keep the smoke layer interface at least 6 feet above any walking surface of a required egress path remote from the fire for a period equal to 1.5 times the calculated egress time or 20 minutes, whichever is greater. According to CBC Section 909.8, smoke control systems using the exhaust method are required to be designed in accordance with NFPA 92 *Standard for Smoke Control Systems*, which permits the use of compartment fire modeling with Computer Fluid Dynamics (CFD) models.

The computer model Fire Dynamics Simulator (FDS) was used to model the atrium space under fire conditions resulting from a number of possible design fires. As required by CBC Section 909, the selection of design fires is based on an engineered rational analysis as documented in this report. Tenability conditions (e.g., temperature, visibility, toxicity) were evaluated in the walkways during the period of occupant egress to demonstrate the ability of occupants to exit the space. The analyses demonstrate that the proposed exhaust quantities for the atrium are sufficient to maintain tenability in the atrium for a period required by code.

2.0 ASSUMPTIONS AND LIMITATIONS

The design objective for the smoke control system is to provide a tenable environment for the evacuation and/or relocation of building occupants in the atrium and communicating occupied spaces. The system was not reviewed for its impact on property protection nor on the suppression or overhaul activities associated with a fire.

The smoke control analysis assumes other life safety and fire protection systems are maintained, available and operational. The analysis assumes, as a minimum, that the automatic sprinklers and fire detection/alarm system installed in the building will function as designed and that the fire resistive construction will be maintained in the building.

The atrium smoke control system will be initiated by smoke detectors and sprinkler actuation. Proper maintenance of these associated devices over the life of the building is necessary to ensure proper activation of the system. Periodic testing of all fans, dampers, makeup air doors, and operating components comprising the smoke management system is also required by the California Fire Code to ensure the functionality of the system over the life of the building.

The smoke control analysis is based on the architectural drawings provided by Noll & Tam Architects, dated August 3, 2020. Any substantial changes to the building design or layout subsequent to this analysis should be reviewed for their potential impact on the smoke control system design.

3.0 BUILDING DESCRIPTION

The building includes 3 above grade levels used for Group A-3, B occupancies and the penthouse used for Group S mechanical space. The total building area is 73,443 square feet. The building includes two enclosed stairs that serve all three floor levels and one open exit access stair serving Levels 1 and 2. There is also an exterior stair that serves the outdoor reading area on Level 2. On each level, there is a centrally located floor opening creating an atrium condition. On Levels 1 and 2, the atrium opens to the adjacent floor spaces without any rated separation. On Level 3, the floor opening is enclosed by glass walls. To achieve the code required 1-hour rated atrium separation, automatic sprinklers will be provided per CBC 404.6 Exception 1 on the floor side of the glass wall. The sprinklers are required to be located between 4 inches and 12 inches from the glass and at intervals along the glass not greater than 6 feet. With the rated separation created by the glass walls and the closely spaced sprinklers, the floor space on Level 3 will be separated from the atrium. The atrium includes the first two levels and the high ceiling pocket created by the glass enclosure on Level 3.

4.0 ATRIUM SMOKE CONTROL DESIGN

According to the interpretation of Division of the State Architect (DSA), an atrium smoke control system is required for the building. The applicable method of smoke control in an atrium is the exhaust method. The atrium smoke control system will include an exhaust system at the top of the atrium and a makeup air supply system supplying fresh air throughout the floor spaces within the open atrium. According CBC Section 909.8, the design objective of the smoke control system using the exhaust method is to keep the smoke layer interface at least 6 feet above any walking surface that forms a portion of a required egress system within the building for a period equal to 1.5 times the calculated egress time or 20 minutes, whichever is greater (CBC 909.4.6).

4.1 Mechanical Exhaust System

The smoke exhaust system proposed for the Laney Library building atrium is an engineered mechanical smoke exhaust system. The system will use the building's relief/smoke exhaust fan RF-1 and RF-2 located in the penthouse to run at a preset speed for smoke control. The relief/smoke exhaust fans serve the atrium space via louvers that are open to the atrium. Level 3 is separated from the atrium by rated barriers. The return air from Level 3 will be through an FSD located in the ceiling of Level 3, which connects Level 3 to the penthouse. During normal operation, the FSD will be open. Level 3 return air will flow through the FSD opening to the penthouse. During a smoke control event, the Level 3 return air FSD will close. The relief/smoke exhaust fans will exhaust smoke through the louvers that are open to the top of the atrium into the penthouse and discharges the smoke to the exterior. The louvers have a total area of approximately 150 square feet. See Figure 1 for the mechanical penthouse plan.

4.2 Makeup Air Supply Systems

In order for the smoke control system to be effective, an adequate amount of makeup air is necessary to replace the smoke being removed. NFPA 92 suggests the makeup air to be 85 to 95 percent of the exhaust rate. Makeup air will be mechanically supplied through the use of building supply air system and VAV boxes. The cooling air handler AHU-C and the heating air handler AHU-H will both be activated upon initiation of the atrium smoke control system and run at its preset smoke control speed. The return dampers (mixing dampers) in the penthouse will be closed. The outside air dampers will be opened. The air handler will supply 100% outside air to the atrium. The makeup air will be supplied to levels 1 and 2 through the supply air ductwork and VAV boxes. No makeup air will be provided on Level 3. The total makeup air supply will be approximately 90 percent of the smoke volumetric exhaust rate calculated for the atrium, which meets the NFPA 92 requirement. NFPA 92 also suggests keeping the makeup air at or below 200 feet per minute to prevent significant plume deflection and disruption of the smoke interface. The computer model has determined that the tenability of the atrium is not adversely affected with the makeup air velocity used in this analysis.

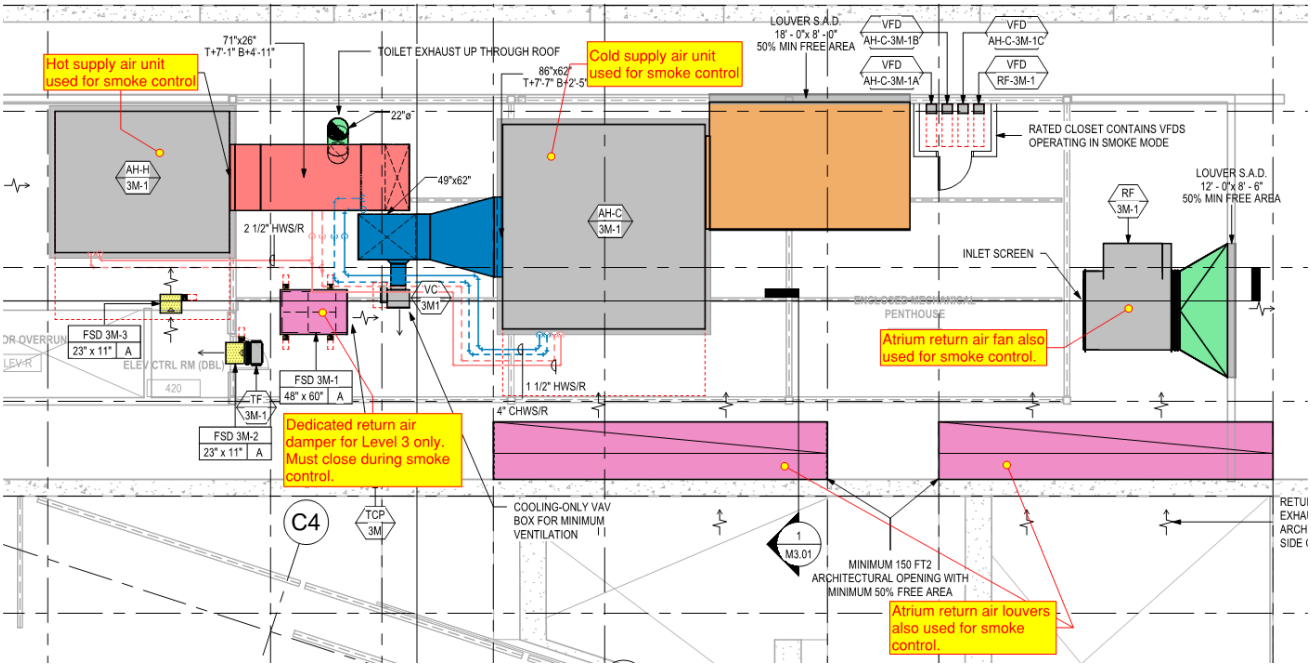


Figure 1 – Mechanical Penthouse Plan

4.3 Detection and Occupant Notifications System

Smoke detection will be provided in strategic places to ensure early smoke detection for occupant egress and smoke control activation. Beam smoke detectors will be installed at the ceiling level of Level 2 across the atrium opening. Additional spot type smoke detectors will be provided at the locations required by code.

The building will also be protected throughout by an automatic sprinkler system. In the event of a smoke detector activation or a sprinkler waterflow switch on Levels 1 or 2, occupant notification is initiated throughout the entire building, giving occupants early warning of a fire condition. Additionally, the atrium smoke control system will automatically activate. A Level 3 sprinkler waterflow or smoke detection alarm will not initiate the atrium smoke control system but will initiate occupant notification throughout the entire building.

4.4 Sprinkler System Design

The building will be provided with an automatic sprinkler system throughout. Anticipated fire sizes for sprinkler-controlled fires were determined using the DETACT model. The input parameters of this model require specific information about the automatic sprinkler system, including temperature rating, response time index (RTI), spacing, and distance of sprinklers above floor level. The following is the minimum automatic sprinkler system design requirements:

- Quick-response sprinklers
- Light Hazard occupancy
- 15 ft maximum spacing
- Maximum 155 degrees Fahrenheit sprinkler temperature rating at regular ceilings and a minimum of 175 degrees Fahrenheit sprinkler temperature rating with glass ceilings.

The sprinkler system shall be provided with separate sprinkler zones on a per floor basis. Separate flow switches shall be provided for each floor.

Although automatic fire sprinkler systems often extinguish fires completely, automatic sprinklers provided in the analysis of this building are only assumed to halt fire growth. As a result, our FDS analysis includes a fire growth phase until sprinkler activation occurs. At this point, the fire growth curve is leveled off and the peak heat-release rate is maintained for the remainder of the simulation.

If the sprinklers are designed with a higher hazard level, the protection level will be improved. Those sprinklers will be spaced closer than what was used in the analysis, which will respond to a fire condition quicker.

5.0 FIRE AND EGRESS ANALYSIS

The mechanical exhaust method is used in the Laney Library atrium to perform smoke clearing and improve tenability for safe evacuation during a fire event in the atrium. The exhaust rate is estimated based on the design fire scenarios using the FDS computer modeling.

The available safe egress time (ASET) is the time from the initiation of the fire to the time when the visibility at 6 feet above any walking surface of an egress path remote from the fire reaches any of the tenability thresholds outlined in this report. For this project, tenability on Levels 1 and 2 is evaluated. Level 3 is separated from the atrium by the code compliant barriers.

The ASET is determined using the FDS model results with a design goal of 20 minutes, or 1.5 the required egress time, whichever is greater. The required safe egress time (RSET) is the time

from the initiation of the fire to the time when the evacuation of occupants from the area of interest is completed. The RSET is determined from an egress analyses, which is included in Appendix B of this report.

The objective of this analysis is to evaluate the building and its systems based on credible design fire scenarios. Unlikely fire scenarios that include fire accelerants as well as arson events are not within the scope of this analysis.

5.1 Fire Scenarios

The fire scenarios simulated in the analysis include areas where there the highest fire growth potential. This includes such considerations as ceiling height for sprinkler activation, combustible load potential, and architectural features that could affect smoke movement. The worst-case scenarios are included in the analysis. Typically, high-ceiling fires located on the lowest level of an atrium generate the most amount of smoke. Therefore, the following fire scenarios have been selected, both of which are located on Level 1 (see Figure 2 for fire locations.

- Scenario 1: Fire in the main open atrium on Level 1
- Scenario 2: Fire at the reception area near the entrance lobby

Figure 2– Fire Locations on Level 1

The soot yield used in both scenarios was 0.05 kilograms of soot produced per kilogram of fuel pyrolyzed. This value represents a combination of wood and plastic fuels expected to be present in the couches, chairs, and tables in the building. This value was chosen based on Table 2-13.1 - Smoke Production for Wood and Plastics, in the SFPE Handbook of Fire Protection

Engineering[1]. The value of 0.05 kilograms per kilogram of soot yield is intended to represent a fuel load that is roughly 50 percent wood and 50 percent plastic. When burning, plastic material generates more smoke than wood. This is considered appropriate for the fuels present.

5.1.1 Rationale for Fire Scenario 1 (Level 1 Open Atrium Space Fire)

Scenario 1 represents the event where the fire is at the high ceiling area on the first level of the atrium. At this location (shown in), tables and chairs for reading and studying are placed under the floor openings of the second and third levels. The sprinklers protecting the area are located approximately 50 feet above the first level floor. At such a high height, sprinkler activation can be greatly delayed. Therefore, it is possible to have a free-burning fire that goes unchecked by an automatic fire suppression system for a long period of time. In the analysis, the fire size and growth rate will be based on an evaluation of actual fuel loads anticipated within the atrium in accordance with CBC Section 909.9. The impact of sprinkler suppression is not included.

Another factor in selecting Scenario 1 is that the fire is located centrally at the bottom of the atrium. This location has a large fire-to-ceiling clearance that provides access for fresh air to infiltrate and mix with the vertically rising smoke plume on all sides, throughout the entire height of the plume. This entrainment and mixing of fresh air expands the smoke's overall volume, which can impact egress. If the fire were located against a wall or in a corner, the plume would not entrain as much air and the overall volume of smoke, as well as its potential impact, would be lessened. The centrally-located fire is considered appropriate for a fire in the atrium space.

5.1.2 Design for Fire Scenario 1

In order to determine the potential fire size, heat release rate curves referenced in the SFPE Handbook of Fire Protection Engineering[2] were selected to represent the fuel load located in the atrium. Shown in Figure 3 are the fire test data for work stations in office spaces. According to the Handbook, the work stations tested contained desks made of modem metal-frame construction with plastic trim parts. In addition, the workstations contained small filing cabinets, telephones, chairs, computers, and a modest amount of office paper. The HRR results for the four-unit workstations are shown in Figure 3-1.61, whereas those for the one workstation units are shown in Figure 3-1.62.

As shown in Figure 3, the peak heat release rate involving four connected work stations, computers, chairs and some loose materials is approximately 3000 kW. The fuel load in the center of the atrium is assumed to be equivalent. The space under the high ceiling area of the atrium is used for study and reading areas. Tables, chairs and computers will likely be placed at this location. In addition, an open exit access stair is located here, which reduces the available

---

[1] Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 3rd Edition, Section 2, Chapter 13, *Smoke Production and Properties*.

2 Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 4th Edition Chapter 3-1 *Heat Release Rate*

floor space that could be used for combustible loading. The rest of the Level 1 space is low ceiling space with sprinkler protection.

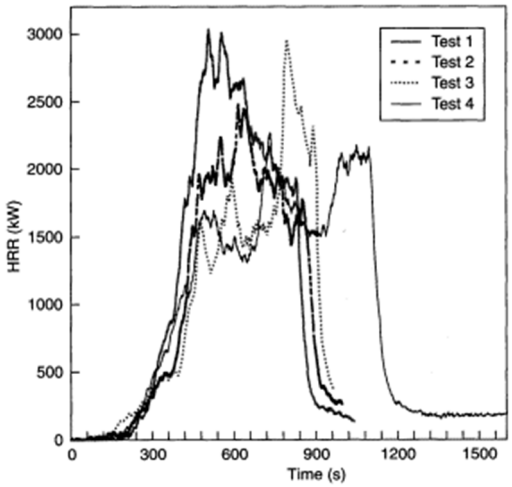


Figure 3-1.61. ***HRR of four unit workstations tested at NRIFD.***

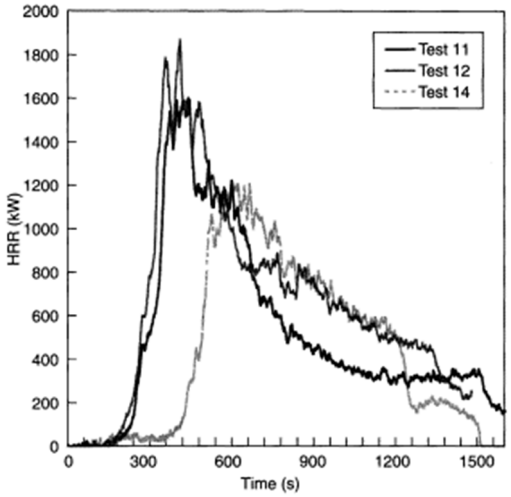


Figure 3-1.62. ***HRR of one unit workstations tested at NRIFD.***

Table 3-1.19 ***Workstations Tested by NRIFD***

Test	Combustible Mass (kg)	Type of Workstation	Number of Desk Units	Partition Panels	Peak HRR (kW)	Time to Peak (s)
1	570	Clerical	4	No	3035	508
2	597	Clerical	4	Yes	2476	616
3	1054	Engineering	4	No	2957	793
4	1086	Engineering	4	Yes	2271	732
11	272	Engineering	1	Yes	1602	441
12	264	Engineering	1	No	1870	412
14	263	Engineering	1	No	1219	601

Figure 3– Fire Test Date from SFPE Handbook

In the computer model, a more conservative fire curve is used. As shown in Figure 4, the fire grows following the t-squared “Fast” fire growth rate as defined by NFPA 92 until the fire size reaches 3,000 kW. This growth rate is consistent with the curve shown in NFPA 92 for a furniture fuel package. The fire size is then stabilized at 3,000 kW for the remainder of the simulation. As a great amount of fuel is required to be present in the atrium to sustain the fire burning at the peak rate, it is considered adding a layer of safety to the smoke control system design.

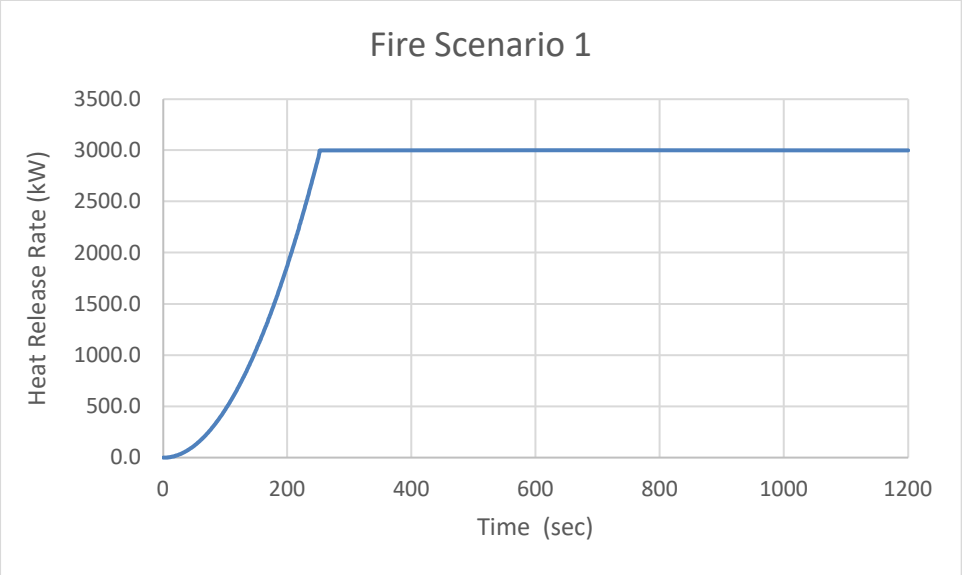


Figure 4– Scenario 1 Level 1 Open Atrium Fire Curve

5.1.3 Rationale for Fire Scenario 2 (Reception Area Fire)

Scenario 2 represents the event where the fire is at the reception area near the entrance lobby on Level 1. At this location (shown in Figure 2), combustible loading is under the 16-foot-tall ceiling. The area will be protected by the building's automatic sprinkler system. It is believed that smoke from a fire in this location will develop into a smoke layer under the ceiling and migrate to the upper levels through the floor opening. A sprinkler-controlled fire size is used in this scenario.

5.1.4 Design for Fire Scenario 2

The sprinklers are located at the ceiling level at 16 feet above the floor. The sprinkler system is assumed to be designed with a maximum spacing of 15 feet for a Light Hazard occupancy. The sprinkler activation temperature is assumed to be 155 degrees Fahrenheit. The fire will grow uncontrolled until the sprinklers activate. The fire growth rate before the sprinkler activation is approximated based upon a t-squared "fast" fire growth as defined by NFPA 92. This growth rate is consistent with the curve shown in NFPA 92 for a furniture fuel package.

For this fire scenario where a fire occurs under the 16-foot ceiling, sprinkler activation is predicted to occur at approximately 132 seconds (2 minutes 12 seconds). At 132 seconds, the DETACT model has been used to predict the fire size to reach 817 kW. Although automatic sprinklers are likely to cause a fire to decay, a steady-state fire condition has been modeled after sprinkler activation occurs until the model ends. As additional amount of fuel is required to be present to sustain the fire burning at the peak rate, this assumption adds a layer of safety to the smoke control system design. The fire curve is included in Figure 5.

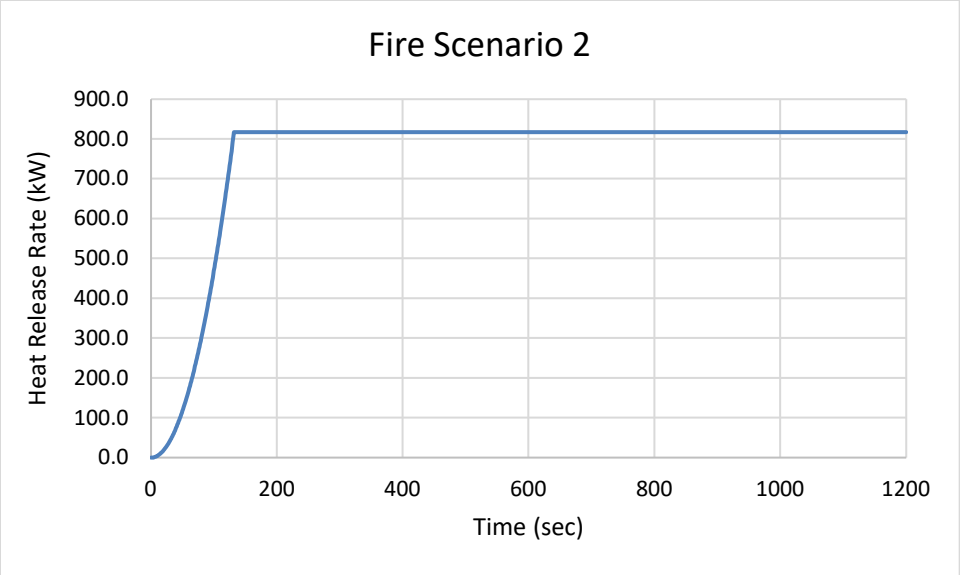


Figure 5– Scenario 2 Reception Area Fire Curve

5.2 Requirement on Potential Combustibles in the Atrium

As the main use at the center of atrium is a reading and studying area, no large quantities of combustible loading is expected. If combustible furniture will be placed inside the atrium space, they should be placed away from the floor openings above and be under or near the low ceiling areas. The low ceiling areas are protected by the automatic sprinkler system, which will control the potential fire sizes, if ignition occurs.

5.3 FDS Computer Modeling

To evaluate the important factors that could impact the efficiency of the exhaust system, including the layout and geometry of the building, the location of the fire, and the location of exhaust fans and makeup air doors, the two fire scenarios were evaluated in Version 6.7.4 of the fire modeling program Fire Dynamics Simulator (FDS). FDS was developed by NIST in Gaithersburg, Maryland. FDS is a CFD model of fire-driven fluid flow. The companion program, Smokeview, is a visualization program that is used to display the results of the simulations.

5.3.1 Model Input Boundary Conditions

5.3.1.1 Geometry

The geometry of the Laney Library building was entered into FDS. Grid sizes of 0.4 meter (wide) by 0.4 meter (long) by 0.4 meter (high) were used for both the fire scenarios.

5.3.1.2 Smoke Generation

The soot yield used in the fire simulations was 0.05 kilograms of soot produced per kilogram of fuel pyrolyzed. This value represents a combination of wood and plastic foam expected to be

present in the sofas, chairs, and tables in the building. This value was chosen based on Table 2-13.1 - Smoke Production for Wood and Plastics, in the SFPE Handbook of Fire Protection Engineering[3]. The 0.05 kilograms per kilogram of soot yield value is intended to represent a fuel that is roughly 50 percent of wood and 50 percent of plastic.

5.3.2 Activation of Smoke Control Systems

The Laney Library building will be provided with an automatic sprinkler system throughout. Beam detectors will be provided across the floor opening at the ceiling level of Level 2. The smoke control system will be initiated upon activation of a sprinkler waterflow switch on Level 1 or Level 2 or a smoke detection alarm within the atrium. It is expected that the smoke detectors will respond to the design fires evaluated within the first 60 seconds. With the consideration of initiation delay of the devices, the smoke control system (mechanical supply and exhaust) is assumed to run at 60 seconds after the fire begins and ramp to its design capacity at 80 seconds.

5.3.3 Tenability Thresholds

The primary goal of the smoke control system is to maintain tenable conditions to enable safe exit accesses. This is achieved by exhausting smoke at such a rate that allows the conditions in the exit access path remain tenable.

The smoke control system is designed according to NFPA 92. The purpose of the proposed design is to exhaust smoke from this space to maintain the smoke layer 6 feet above any walking surface of the egress route in the building area.

The horizontal planes located 6 feet above the floor slab of Levels 1 and 2 are the areas of concern and served as the focus for review in the FDS analyses. The parameters examined within FDS to determine tenability at these locations were visibility, temperature, and Carbon Monoxide. The following information from the SFPE Handbook is used to determine tenability thresholds.

5.3.3.1 Visibility

The visibility value[4] is denoted as S. It is calculated via the equation, S=C/K, where K is the light extinction coefficient. C is a constant characteristic of the type of object being viewed through the smoke. C equals 3 corresponds to visibility through smoke for a light-reflecting sign and C equals 8 for a light-emitting sign. All simulations performed for this analysis were performed with the lower constant of 3 for reflecting surfaces (non-illuminated). As illuminated exit signs will be provided throughout the building, using the lower C value adds conservatism in the analysis, which addresses occupant's wayfinding ability through studying furniture.

---

[3] Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 3rd Edition, Section 2, Chapter 13, *Smoke Production and Properties*

[4] Fire Dynamics Simulator (Version 6) Users Guide

For evaluation of the smoke layer within the building, a visibility of 9.1 meters (30 feet) was used as the threshold. Jin[5] suggested that when visibility is maintained at 9.1 meters or greater, occupants are generally assumed to continue to exit the building. Under this circumstance, normal egress times are anticipated. Where the visibility distance is less than 9.1 meters, occupants of the building are assumed to slow their egress progress through the building.

5.3.3.2 Temperature

Purser[6] suggested a correlation between the exposure time and the thermal tolerance for humans at rest, naked skin exposed, with low air movement. For an exposure time of approximately 20 minutes, 80 degrees Celsius (176 degrees Fahrenheit) is the highest temperature a human can sustain without adverse physical effects. In the event the air is water-saturated, a limit of 60 degrees Celsius (140 degrees Fahrenheit) is the maximum temperature that is breathable for 20 minutes. The air is likely to contain a considerable amount of moisture as the products of combustion include water. Therefore, a temperature of 60 degrees Celsius or less was used herein as a tenable environment.

5.3.3.3 Carbon Monoxide

In this project, the Carbon Monoxide (CO) level in the building was not monitored. The smoke control system involves exhausting and supplying a large amount of air throughout the smoke control duration. It is expected that the CO level will not be a concern. The CO level may be a concern when working with a small and enclosed space.

6.0 RESULTS SUMMARY

The FDS simulations prove that exhausting smoke at 80,000 cfm allows the exit paths to remain tenable on floors remote from the fire. Results of the Scenario 1 and Scenario 2 models are arranged according to the particular fire scenario. FDS slice files showing visibility and temperature at the worst-case time of each fire scenario are provided in Appendix C of this report. Because the fire is steady state after the growth phase, the worst-case time is at the end of the simulation.

6.1 Fire Scenario 1 Results

6.1.1 Egress Results

According to the egress analysis in Appendix B of the report, it takes all the occupants on Levels 1 and 2 a total of 16.9 minutes (which includes detection delay, notification delay, pre-movement

[5] SFPE Handbook, 3rd edition, Section 2 Chapter 4, *Visibility and Human Behavior in Fire Smoke*

[6] Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 3rd Edition, Section 2, Chapter 6, *Toxicity Assessment of Combustion Products*

delay, and a safety factor) to exit the building. As the stair enclosures are 1-hour rated as required by code, the occupants are considered evacuated from the atrium and in a safe environment once they enter the stair enclosures. However, because one of the stairs discharges into the atrium on Level 1, the time to exit the building is used as the required safe egress time (RSET) for comparison to the available safe egress time (ASET) as determined by the FDS analysis.

In the analysis, the open stair is not included in the egress time calculation. It is assumed the smoke and heat from an atrium fire will rise through the large floor opening, which will discourage occupants to use the open stair located in the floor open. This assumption reduces the available egress width and increases the egress time on Level 2 and adds conservatism in the analysis.

6.1.2 FDS Fire Modeling Results

The simulation time for Fire Scenario 1 is 20 minutes. In this scenario, the fire is located in open atrium area on Level 1. The beam detectors activate early to activate the smoke control system.

Other than the fire location, the visibility and temperature on both levels remain tenable throughout the atrium for the entire 20-minute duration.

6.1.3 Conclusion

The Scenario 1 model results are considered acceptable, because they show that the proposed smoke control system will meet the design goal of maintaining tenable conditions on floors remote from the fire. The available time for safe evacuation is at least 20 minutes, which exceeds the 1.5 times the calculated egress time.

6.2 Fire Scenario 2 Results

6.2.1 Egress Results

According to the egress analysis in Appendix B of the report, it takes all the occupants on Levels 1 and 2 a total of 16.9 minutes (which includes detection delay, notification delay, pre-movement delay, and a safety factor) to exit the building. As the stair enclosures are 1-hour rated as required by code, the occupants are considered evacuated from the atrium and in a safe environment once they enter the stair enclosures. However, because one of the stairs discharges into the atrium on Level 1, the time to exit the building is used as the required safe egress time (RSET) for comparison to the available safe egress time (ASET) as determined by the FDS analysis.

In the analysis, the open stair is not included in the egress time calculation. It is assumed the smoke and heat from an atrium fire will rise through the large floor opening, which will discourage occupants to use the open stair located in the floor open. This assumption reduces the available egress width and increases the egress time on Level 2 and adds conservatism in the analysis.

6.2.2 FDS Fire Modeling Results

The simulation time for Fire Scenario 2 is 20 minutes. The fire is located in the reception area. The smoke travels through Level 1 to spill into the open atrium area.

Other than in the vicinity of the fire location, the visibility and temperature on both levels remain tenable throughout the atrium for the entire 20-minute duration.

6.2.3 Conclusion

The Scenario 2 model results are considered acceptable, because they show that the proposed smoke control system will meet the design goal of maintaining tenable conditions on floors remote from the fire. The available time for safe evacuation is at least 20 minutes, which exceeds the 1.5 times the calculated egress time.

7.0 EXHAUST METHOD REQUIREMENTS

Successful smoke control with mechanical ventilation for the building depends upon the strategic location of the exhaust vents and makeup air inlets, the size of the clear opening of the vents and air inlets, and the three parameters (visibility, temperature, carbon monoxide concentration) discussed above.

7.1 Exhaust Fans

Smoke control for the Laney Library atrium is accomplished through the use of the relief/smoke exhaust fans located in the penthouse. The required exhaust capacity is calculated to be 80,000 cfm. The exhaust louver openings have a total area of approximately 150 square feet.

The model determines the exhaust volume necessary to maintain tenable conditions. The mechanical designer of record must determine the appropriate fan size based upon ductwork and fan operation at the project site elevation.

7.2 Makeup Air

Makeup air will be mechanically supplied through the use of building supply air system and VAV boxes. The cooling air handler AHU-C and the heating air handler AHU-H will both be activated upon initiation of the atrium smoke control system and run at its preset smoke control speed. The return dampers (mixing dampers) in the penthouse will be closed. The outside air dampers will be open. The air handler will supply 100% outside air to the atrium. The makeup air will be supplied to levels 1 and 2 through supply air ductwork and VAV boxes. A supply free area of 290 ft^2 was incorporated in the FDS model providing a total of 72,000 cfm of makeup air. Each level will be provided with approximately 36,000 cfm makeup air. All the dampers located in the penthouse are required to be controlled and individually monitored by the building's fire alarm system. The dampers must fail to their smoke mode positions. All the VAV boxes on Levels 1 and 2 are required to fail open. The open/closed position of the VAV boxes are required to be monitored by the fire alarm system. There are no control or monitoring requirements for the VAV boxes on Level 3, as they are located outside the atrium boundary.

The area of makeup air vent assumed in the computer model is a geometric-free area. The makeup air locations have been strategically placed to provide sufficient makeup air to prevent over pressurization of the building and prevent disruption of the fire plume as a result of makeup

air velocity. The supply openings provided will create a makeup air velocity of approximately 250 ft/min and was incorporated into the FDS model to verify that its effects do not negatively affect the smoke control system's performance.

8.0 SMOKE CONTROL SYSTEM ACTIVATION

8.1 Smoke Control Activation Criteria

The Laney Library building will be provided with an automatic sprinkler system throughout. In addition, beam detectors will be installed at the Level 2 ceiling level across the floor opening. Additional spot type smoke detectors will be provided at the locations required by code. The smoke control system will be initiated upon activation of a sprinkler waterflow switch or a smoke detector alarm on Levels 1 and 2.

8.2 Smoke Control Activation Sequence

In the event of an alarm reported to the fire alarm panel through activation of a smoke detector or sprinkler waterflow alarm on Levels 1 and 2, occupant notification will be initiated throughout the entire building. The following sequence of operation will occur. See Appendix A for a detailed sequence operations matrix.

- The relief/smoke exhaust fans (RF-1, RF-2) will run at its preset smoke control speed and the associated outside air dampers will open.
- The air handlers (AHU-C and AHU-H) will run at their preset smoke control speed, the associated outside air dampers will open, and the associated return dampers will close.
- The Level 3 supply shaft damper and the return air damper in the ceiling will close.
- The supply shaft dampers on Levels 1 and 2 open and all VAV boxes on Levels 1 and 2 fully open.
- All other FSDs will close.
- Level 1 horizontal sliding fire door at Stair A will close.
- Level 1 and Level 2 ceiling fans will shut down.

9.0 EQUIPMENT

Equipment such as, but not limited to, fans and ducts, are to be suitable for their intended use and approved by the authority having jurisdiction. The following sections list and describe the requirements applicable for the equipment of the Laney Library building atrium smoke control systems. This is not a complete list of code requirements.

9.1 Duration of Operations

CBC 909.4.6 requires all portions of active or engineered smoke control systems to be capable of continued operation after detection of the fire event for a period of not less than either 20 minutes or 1.5 times the calculated egress time, whichever is greater.

The egress analysis (see Appendix B) indicates that the maximum egress time within the atrium is 16.9 minutes. Therefore, the atrium smoke control system is required to operate for a minimum of 20 minutes after activation to satisfy the code requirement.

Table 1 Egress Calculation Summary of Atrium Levels

Floor Levels	Required Egress Time (including the 1.5 Factor of Safety)
Level 2	16.9 min
Level 1	7 min

9.2 Exhaust Fan

Components of the smoke control exhaust fan are to be rated and certified by the manufacturer for the probable temperature rise to which the components will be exposed. A smoke layer temperature of 200 degrees Fahrenheit was found at the level of the return openings. Therefore, an exhaust fan rated for smoke control for a temperature of at least 250 degrees Fahrenheit should be used. Belt-driven fans are required to have 1.5 times the number of belts required for the design duty with the minimum number of belts being two. The fans are to be supported and restrained by non-combustible devices. Motor-driven fans may not operate beyond their nameplate horsepower as determined from measurement of actual current draw.

Monitoring of the exhaust fan shall be provided by sensing the air flow downstream of the fan using pressure differential switches or transmitters or by current switches located on the load side of the VFD or starter. If current switches are used then they must be sufficiently sensitive to sense a loss in current due to fan failure or if a belt drops. Current switches must be “wrapped” by the power wire at least 5 times to ensure sufficient sensitivity. VFD relay output contacts can be used for power loss and off statuses but cannot be used for on status. Current switches shall not be located within the VFD or fan starter enclosure. They shall be located within a separate electrical junction box or similar.

If a variable frequency drive (VFD) is used to control the fans then they must be provided with fire mode contacts so that fire alarm has the highest priority to activate or shut down the fan.

9.3 Supply Fans

The supply fans used for smoke control makeup air are not expected to be exposed to high temperatures or smoke and do not need to be rated for this purpose. Belt-driven fans are required to have 1.5 times the number of belts required for the design duty with the minimum number of belts being two. The fans are to be supported and restrained by non-combustible devices. Motor-driven fans may not operate beyond their nameplate horsepower as determined from measurement of actual current draw.

Monitoring of supply fans shall be provided by sensing the air flow downstream of the fans using pressure differential switches or transmitters or by current switches located on the load side of each VFD or starter. If current switches are used then they must be sufficiently sensitive to sense a loss in current due to fan failure or if a belt drops. Current switches must be “wrapped” by the

power wire at least 5 times to ensure sufficient sensitivity. Current switches shall not be located within the VFD or fan starter enclosure. They shall be located within a separate electrical junction box or similar.

If a variable frequency drive (VFD) is used to control the fans then they must be provided with fire mode contacts so that fire alarm has the highest priority to activate or shut down the fan.

9.4 Ducts

If provided, ducts are to be capable of withstanding the probable temperatures and pressures to which they are exposed. Ducts are to be supported directly from fire-resistance-rated structural elements of the building by substantial, non-combustible supports.

9.5 Fire/Smoke Dampers

All fire/smoke dampers used to separate the atrium for adjacent spaces or to redirect supply air for smoke control make-up air must be individually monitored. The supply shaft FSDs must be controlled separately to provide make-up air to the atrium. All dampers shall be a minimum leakage class II and 250°F rated. Temperature activation switches shall be set to 165°F. Dual temperature switch FSDs should not be provided.

9.6 Control Dampers

The control dampers located in the penthouse should be leakage rated. The dampers should be fitted with end switches for monitoring by the fire alarm system. The motors should be installed so that the dampers fail to their smoke mode positions. Power monitoring is not required where the dampers fail to their smoke mode positions.

10.0 POWER SYSTEMS

CBC Section 909.11 requires the smoke control system to be supplied with two sources of power: normal power and standby power. Primary power is required to be from the normal building power systems. Secondary power is required to be from an approved standby source complying with CBC Chapter 27.

The standby power source and its transfer switches are required to be in a room separate from the normal power transformers and switch gears and ventilated directly to and from the exterior. The room is required to be enclosed with not less than 1-hour fire barriers constructed.

The secondary power source is required to be capable of supplying power to maintain continued operation of the smoke control system for a minimum duration of 30 minutes.

11.0 DETECTION AND CONTROL SYSTEMS

Supervision of the fire alarm system is required to provide positive confirmation of actuation, testing of devices, manual override mechanisms, and the presence of power downstream of all disconnects.

The fire alarm system shall control the atrium smoke control system and shall be UUKL-Listed for smoke control.

11.1 Wiring

All wiring associated with the smoke control system, regardless of voltage, shall be in continuous raceways (conduit or equivalent). This includes all power wiring for smoke control equipment and all initiating device circuits serving smoke detection devices within the atrium.

11.2 Activation

The fire alarm system shall have complete override control of all mechanical equipment used for the smoke control system.

11.3 Automatic Control

The automatic-control sequences are to be initiated from the smoke detection system or the automatic sprinkler system. A means for manual activation is required to be provided at the firefighter's control panel.

12.0 FIREFIGHTER'S CONTROL PANEL

A firefighter's smoke control panel is to be provided for fire department emergency response purposes. This is to include manual control or override of automatic control for the smoke control system. The firefighter's control panel location should be approved by the AHJ.

The firefighter's control panel graphic shall accurately show the location of equipment within the atrium.

12.1 Smoke Control Capability

The firefighter's control panel is required to provide control capability over the complete smoke control system equipment within the building as follows:

- ON-AUTO-OFF or OPEN-AUTO-CLOSE controls over each individual piece of operating smoke control equipment that can also be controlled from other sources within the building.
- ON-OFF or OPEN-CLOSE controls over smoke control and other critical equipment associated with a fire or smoke emergency that can only be controlled from the firefighter's control panel.
- Each group of equipment should have individual status lights for the use of firefighter operations as well as smoke control system maintenance and testing purposes. These status lights shall be real time whether the system is active or not. Each group should have the following status lights.
    - NORMAL (white): Illuminates when the group is not being commanded by the smoke control system.
    - ON/OPEN (green) and/or OFF/CLOSED (red)
    - FAULT (amber): Illuminates when a piece of equipment in the group has lost power (if power is necessary for smoke mode position) or a piece of equipment in the group fails to configure to its commanded position.

For this project, the following should be incorporated into the design of the firefighter's control panel.

Table 2—Firefighter's Control Panel Features

SYSTEM	CONTROL	INDICATION LIGHTS
Relief/Smoke Exhaust Fans (RF-1, RF-2)	ON/OFF/AUTO (One switch for fan and dampers)	ON/OFF/FAULT/NORMAL (One set of indicator lights)
Relief Associated Outside Air Dampers		OPEN/FAULT/NORMAL (One set of indicator lights)
Two Air Handlers (AHU-C, AHU-H)	ON/OFF/AUTO (One switch for both AHUs and dampers)	ON/OFF/FAULT/NORMAL (One set of indicator lights)
Air Handler Associated Outside Air Dampers		100% OUTSIDE AIR/FAULT/NORMAL (One set of indicator lights)
Air Handler Associated Return Air Dampers		
Level 3 Supply FSDs	CLOSED/AUTO (One switch)	OPEN/CLOSED/FAULT/NORMAL (One set of indicator lights)
Level 3 Return FSD		OPEN/CLOSED/FAULT/NORMAL (One set of indicator lights)
Level 2 Supply FSDs	OPEN/CLOSED/AUTO (One switch)	OPEN/CLOSED/FAULT/NORMAL (One set of indicator lights)
Level 2 VAV Boxes		OPEN/FAULT/NORMAL (One set of indicator lights)
Level 1 Supply FSDs	OPEN/CLOSED/AUTO (One switch)	OPEN/CLOSED/FAULT/NORMAL (One set of indicator lights)
Level 1 VAV Boxes		OPEN/FAULT/NORMAL (One set of indicator lights)

12.2 Control Actions and Priorities

The firefighter's control panel actions are required to be as follows:

- All control switches on the firefighter's control panel must have the highest priority of any control point within the building. Once a command is issued from the firefighter's control panel, no automatic or manual control from another other control point within the building is to contradict the control action except for electrical code required disconnects.

- Where automatic means are provided to interrupt normal, non-emergency equipment operation or produce a specific result to safeguard the building or equipment, such means will be capable of being overridden by the firefighter's control panel control action and the last control action as indicated by each firefighter's control panel switch position will prevail.
- Only the AUTO position of each three-position firefighter's control panel switch is to allow automatic or manual control action from other control points within the building. When a firefighter's control panel is in the AUTO position, the actual status of the device (ON, OFF, OPEN, CLOSED) is to continue to be indicated by the status indicator described above.

13.0 WEEKLY SELF-TEST

The weekly self-test shall exercise all fans, dampers, and VAV boxes indicated in Section 12.1 and Table 2 of this report. When the smoke exhaust fans are activated, the make-up air fans must be activated simultaneously to prevent excessive negative pressure within the atrium. All fire/smoke dampers and control dampers must be opened and closed as part of the test. The weekly self-test sequence report shall indicate all abnormal conditions audibly (fire alarm control panel), visibly (firefighter's control panel) and by printed report (fire alarm printer). The weekly self-test sequence shall also print a report if the test passes.

14.0 CONCLUSION

This Smoke Control Rational Analysis details the atrium smoke control system proposed for the Laney Library building. Based on the engineering analysis documented herein, the proposed atrium smoke control system will meet the performance goal, which is to maintain tenability to allow safe evacuation during a fire event.

Sincerely,

Xin Liu, P.E.
Senior Fire Protection Engineer
Fire & Risk Alliance, LLC

Jeff Paterson, P.E.
Senior Fire Protection Engineer
Fire & Risk Alliance, LLC

APPENDIX A

SEQUENCE OF OPERATIONS MATRIX

	Air Handlers				Fire/Smoke Dampers			VAV Boxes			
Initiation Device	**Supply AHUs (AHU-C, AHU-H)**	**Relief/Smoke Exhaust Fans (RF-1, RF-2)**	**Outside Air Dampers**	**Return Air Damper**	**Supply Shaft FSDs (Levels 1 and 2)**	**Supply Shaft FSDs and Return FSD (Level 3)**	**All Other FSDs**	**VAV Boxes (Levels 1 and 2)**	**VAV Boxes (Level 3)**	**Level 1 Horizontal Sliding Fire Door at Stair A**	**Hold-open Doors**
Atrium Smoke Detection[(2)]	On	On	Open	Close	Open	Close	Close	Open		Close	Close
Non-Atrium Smoke Detection[(3)]											
Atrium Sprinkler Waterflow	On	On	Open	Close	Open	Close	Close	Open		Close	Close
Non-Atrium Sprinkler Waterflow											
Manual Pull Station											
FSD Duct Smoke Detector					Close[(6)]	Close[(6)]	Close[(6)]				
Supply Fan Duct Smoke Detector	Off[(5)]				Close[(5)]	Close[(5)]					

Notes:

1. Blank cells indicate that the fire alarm system does not issue a command to the device.

2. Smoke Detection initiating devices include: Any area smoke detector, elevator lobby smoke detectors, horizontal sliding fire door associated smoke detector, and beam detector.

3. Non-Atrium Smoke Detection devices include devices such as Level 3 detectors, electrical room detectors, hoistway detectors.

4. All other initiating devices not listed will perform their normal fire alarm functions and do not activate smoke control.

5. Supply fan duct detector shut down and FSD closure shall be overriden when commanded from the firefighter's control panel.

6. Associated FSD only closes upon duct smoke detection.

APPENDIX B

TIMED EGRESS CALCULATIONS

Timed Egress Calculation for

Required Safe Egress Time (RSET)

RSET is based upon a summation of events that begins at the initiation of the fire event and finishes when the evacuation of occupants from the area of interest is complete.

$RSET^{7} = t_d + t_a + t_o + t_i + t_e$

t_d: time from fire ignition to detection

t_a: time from detection to notification of occupants of a fire emergency

t_o: time from notification until occupants decide to take action

t_i: time from decision to take action until evacuation commences

t_e: time from the start of evacuation until it is completed

For this project, the following delays have been assumed and discussed in the main body of the report.

Detection and Alarm Time ($t_d + t_a$) = 1 minutes

Pre-Movement Delay Time ($t_o + t_i$) = 3 minutes

The occupant load and exit capacity are based on architectural sheets G1.31 of the 50% CD Set, dated 8/3/2020.

Floor Levels	Occupant Load
1	756
2	683
3	326

[7] Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 3rd Edition, Section 3, Chapter 13, *Movement of People: The Evacuation Timing*.

Level 1

According to the architectural drawing, a total of 756 occupants are estimated on Level 1. Level 1 includes five exterior exit locations. One exit is in the main entrance lobby (Exit 1). Two exits are located in the open tutoring space (Exit 4 and Exit 5). One exit serves the Instructional Lab only (Exit 6) and one exit is located in the Staff Entry/Delivery Area (Exit 2).

According to Table 3-13.5, and Table 3-14.4 in the SFPE Handbook of Fire Protection Engineering, the unimpeded speed of travel is approximately 236 feet per minute (ft/min) to 250 ft/min. In this analysis, a travel speed of 200 ft/min is used, which adds conservatism to the analysis.

- Total occupant load on Level 1: 756 people

- Horizontal Travel Time on Level 1:
  - Approximate worst-case travel distance to a stair door: 160 feet
  - Egress travel speed = 200 ft/min
  - Travel time = (160 ft) / (200 ft/min) = **0.8 minutes**

- Delay passing through Lever 1 exit doors is calculated as follows:
  - The majority of the occupants will egress through the main entrance and the two exits in the open tutoring area. Therefore, the limiting egress time will be governed by the egress speed through these exits. The following calculation will be focused on the egress speed through these three exits.
  - Available exits: Two 6-foot main entrance doors and two 3-foot doors
  - Total effective door width (with boundary layer reduction):

    W_e = (6.5ft + 6.5ft + 3ft + 3ft) – 12-inch boundary layer x 4 doors = 15 ft
  - Specific flow through the doors: F_{sm} = 24 people / (min ft)
  - Total flow of all doors: F_c = 24 people / (min ft) x 15 ft = 360 people/min
  - Total occupants using the exits: 355+178+178= 711 people
  - Time through three exit doors = (711 people) / (360 (people)/min) = **2.0 minutes**

- As shown above, it takes the occupants a maximum of 0.8 minutes to reach the nearest exit door. After 0.8 minutes, occupants are queuing at the exit doors waiting to enter the stair. The time for a total of 711 occupants to all egress through these exit doors is 2.0 minutes, which is longer than the time needed for the occupants to reach the doors. Therefore, queueing is expected at the exit doors on Level 1.

Table 1. Egress Calculation Summary of Level 1

Timed Egress Components	**Time Taken**	**Where Queueing Occurs**
Detection time: $t_d + t_a$	**1** min	
Pre-movement time: $t_o + t_i$	**3** min	
Time to travel to exit doors	0.8 min	
Time through width of exit doors	**2.0 min**	**Queuing**
Total egress travel time: t_e	**2.0 min**	
1.5 x total egress travel time: 1.5 t_e	**3.0 min**	
Total egress time ($t_d + t_a + t_o + t_i + 1.5\ t_e$)	**7.0 min**	

Level 2

According to the architectural drawing, a total of 707 occupants are estimated on Level 2 with 683 located in the building and 24 located at the outdoor rating area. Egress speed is limited by the width of the exit doors and the width of the stairs.

Level 2 includes two enclosed stairs, one open stair and one exterior stair. For evaluating the egress condition during a smoke control event, it is assumed that no occupants will egress through the open stair in the atrium as smoke will rise through the large floor open. This is considered a conservative approach, as it reduces the available exits and increase the egress time on Level 2. The exterior stair is connected to an outdoor reading area of approximately 1200 square feet. For the occupants using the exterior stair, it is assumed that the occupants are in a smoke free environment once they reach the outdoor reading area. The outdoor reading area provide adequate space to accommodate the occupants in the area and the occupants exiting into the space. Additional time required for them to egress to grade using the exterior stair is not calculated.

- Total occupant load on Level 2: 707 people
  - Stair A, Stair B and the exterior stair will each serve 1/3 of the total occupant load on Level 2.

- Horizontal Travel Time on Level 2:
  - Approximate worst-case travel distance to an exit door: 130 feet
  - Egress travel speed = 200 ft/min
  - Travel time = (130 ft) / (200 ft/min) = **0.7 minutes**

- Delay of using the Level 2 stairs is calculated as follows:
  - It is assumed that a fire alarm event will initiate a full building evacuation. Occupants from Level 3 will evacuate through the two enclosed stairs, which will impact the egress speed of the occupants using the stairs on Level 2.

- Specific flow through each stair, assuming 7-inch riser and 11-inch tread: F_{sm} = 18.5 people/min/ft

Stair A

- Available exit doors of Stair A: One 8-foot stair door
- Effective door width of Stair A (with boundary layer reduction):

  W_e = 8ft – 12-inch boundary layer = 7 ft
- Specific flow through doors: F_{sm} = 24 people / (min ft)
- Flow of stair door: Fc = 24 people / (min ft) x 7 ft = 168 (people)/min
- 1/3 of Level 2 occupants using Stair A: 236.
- Time delay for Level 2 occupants to exit through the Stair A door

  = (236 people) / (168 (people)/min) = **1.4 minutes**
- Effective stair width of Stair A (with boundary layer reduction):

  W_e = 6 ft – 12-inch boundary layer = 5 ft
- Flow of stairs: F_{sm} = 18.5 people / (min/ft) x 5 ft = 92 people/minute
- 1/3 of Level 2 occupants using Stair A: 236.
- Time through stair width = 236 people / (92 people/minute) = **2.6 minutes**
- Travel on Stair Time:

  Maximum occupant density in the stairs is 0.175 p/sq.ft (Handbook of Smoke Control Engineering, Chapter 4)

  Egress speed traveling down stairs based on maximum occupant density

  = 106 ft/min (Handbook of Smoke Control Engineering, Chapter 4)

  Travel distance on Stair =70 feet

  Travel time on Stair = 70 ft / (106 ft/min) = **0.7 minutes**
- Total occupants in Stair A: 236 from Level 2 + 163 from Level 3 = 399 occupants
- Flow at Level 1 discharge will be limited by the capacity of the stair. As a horizontal sliding fire door will be provided at Stair A on Level 1, the egress capacity can be adjusted to accommodate the stair flow.

  399 occupants/ (92 people/minute) = **4.4 minutes**
- The time for the occupants to get onto the stair and the time for the occupants to travel on the stair is less than the discharge time at the bottom stair, which includes occupants on both Level 2 and 3. Therefore, the bottom discharge speed is the controlling factor. Queuing will occur at the bottom stair.
- After the occupants discharge to the first floor, the occupants from the Stair A will travel inside the building to reach the building exterior exit doors. Additional travel time on the first floor = 35 feet / (200 ft/minute) = **0.1 minute**
- Flow through two 6-foot main entrance doors

  Total effective door width (with boundary layer reduction):

W_e = (6.5 ft + 6.5 ft) – 12-inch boundary layer x 2 doors = 11 ft

Specific flow through the doors: F_{sm} = 24 people / (min ft)

Total flow of all doors: F_c = 24 people / (min ft) x 11 ft = 264 people/min

- As the bottom stair discharge the occupants at slower speed than the flow a capacity of the exterior doors, the bottom stair discharge speed is the controlling factor. Additional queuing time is not anticipated at the main entrance door.

Stair B

- Available exit doors of Stair B: One 3-foot stair door
- Effective door width of Stair B (with boundary layer reduction):

  W_e = 3ft – 12-inch boundary layer = 2 ft
- Specific flow through doors: F_{sm} = 24 people / (min ft)
- Flow of stair door: Fc = 24 people / (min ft) x 2 ft = 48 (people)/min
- 1/3 of Level 2 occupants using Stair B: 236.
- Time delay for Level 2 occupants to exit through the Stair B door

  = (236 people) / (48 (people)/min) = **4.9 minutes**
- Effective stair width of Stair B (with boundary layer reduction):

  W_e = 3.5 ft – 12-inch boundary layer = 2.5 ft
- Flow of stairs: F_{sm} = 18.5 people / (min/ft) x 2.5 ft = 46 people/minute
- 1/3 of Level 2 occupants using Stair B: 236.
- Time through stair width = 236 people / 46 people/minute = **5.1 minutes**
- Travel on Stair Time:

  Maximum occupant density in the stairs is 0.175 p/sq.ft (Handbook of Smoke Control Engineering, Chapter 4)

  Egress speed traveling down stairs based on maximum occupant density

  = 106 ft/min (Handbook of Smoke Control Engineering, Chapter 4)

  Travel distance on Stair =55 feet

  Travel time on Stair = 55 ft / (106 ft/min) = **0.5 minutes**

- Total occupants in Stair B: 236 from Level 2 + 163 from Level 3 = 399 occupants
- Flow through bottom stair

  =399 occupants / [18.5 people / (min/ft) x 2.5 ft] = **8.6 minute**
- Flow capacity of the 3-foot bottom discharge stair door:

  F_{sm} = 24 people / (min/ft) * 2 ft = 48 people/minute
- Flow through the 3-foot bottom discharge door

  =399 occupants / [24 people / (min ft) x 2 ft] = **8.3 minute**
- The time for the occupants to get onto the stair and the time for the occupants to travel on the stair is less than the discharge time at the bottom stair. Therefore, the

bottom discharge speed is the controlling factor. Queuing will occur at the bottom stair. The bottom stair door has a slightly faster flow rate than the stair flow. No additional queuing is anticipated at the stair discharge door.

Exterior Doors at Outdoor Reading Area

- Total effective door width of the two 3-foot doors leading to the exterior stair (with boundary layer reduction):

  W_e = (3ft + 3ft) – 12-inch boundary layer x 2 doors = 4 ft
- 1/3 of Level 2 occupants using exterior stair: 235.
- Flow of two exterior doors: Fc = 24 people / (min ft) x 4 ft = 96 (people)/min
- Time delay for Level 2 occupants to exit toward the exterior stair

  = (235 people) / (96 (people)/min) = **2.5 minutes**
- It is assumed that all occupants will be in the outdoor space after 2.5 minutes. According to CBC 1026.4.1, the floor space of each occupant waiting to egress is estimated to be 3 square feet. The outdoor space is approximately 1200 sf, which will accommodate all the occupants egressing this direction.

Table 2. Egress Calculation Summary of Level 2

	Horizontal Time (min)	Time through Door (min)	Time through Stair (min)	Travel on Stair (min)	Bottom Stair Discharge (min)	Stair Door Discharge (min)	Horizontal Travel on Level 1 (min)	Total Egress Travel Time (min)
Stair A	0.7	1.4	2.6 (queuing on floor)	0.7	**4.4** (queuing in stair)	--	**0.1**	**4.5**
Stair B	0.7	4.9 (queuing on floor)	5.1	0.5	**8.6** (queuing in stair)	8.3	--	**8.6**
Exterior Area	0.7	**2.5** (queuing) on floor	--	--	--	--	--	**2.5**

Table 3. Total Egress Time of Level 2

Timed Egress Components	**Time Taken**
Detection time: $t_d + t_a$	1 min
Pre-movement time: $t_o + t_i$	3 min
Total egress travel time: t_e	8.6 min (based on Stair B condition)
1.5 x total egress travel time: 1.5 t_e	12.9 min
Total egress time ($t_d + t_a + t_o + t_i + 1.5\ t_e$)	**16.9 min**

Level 3

Level 3 is separated from the atrium by code compliant smoke barrier construction. In an atrium fire event, the occupants on Level 3 is not exposed to the smoke and heat condition. Therefore, egress analysis is not conducted on this floor.

Summary

The required egress time for the atrium levels are summarized below.

Table 4. Egress Calculation Summary of Atrium Levels

Floor Levels	Required Egress Time
Level 2	16.9 min
Level 1	7 min

APPENDIX C

FDS SLICE FILES

FDS Fire Simulation Results

The FDS Version 6.7.4 was used in this project. The key input parameters are as follows:

Table C1 - FDS Results

Simulation cell size	0.4 m (W) x 0.4 m (L) x 0.4 m (H)
Fuel Type	50 percent wood + 50 percent plastic
Soot Yield	0.05 kg/kg
Visibility Factor	3
Peak Fire Size (Scenario 1)	3000 kW (open atrium fire)
Peak Fire Size (Scenario 2)	817 kW (reception fire)
Total Duration (Scenario 1)	20 minutes
Total Duration (Scenario 2)	20 minutes

The scales on the slice files are set in the following way:

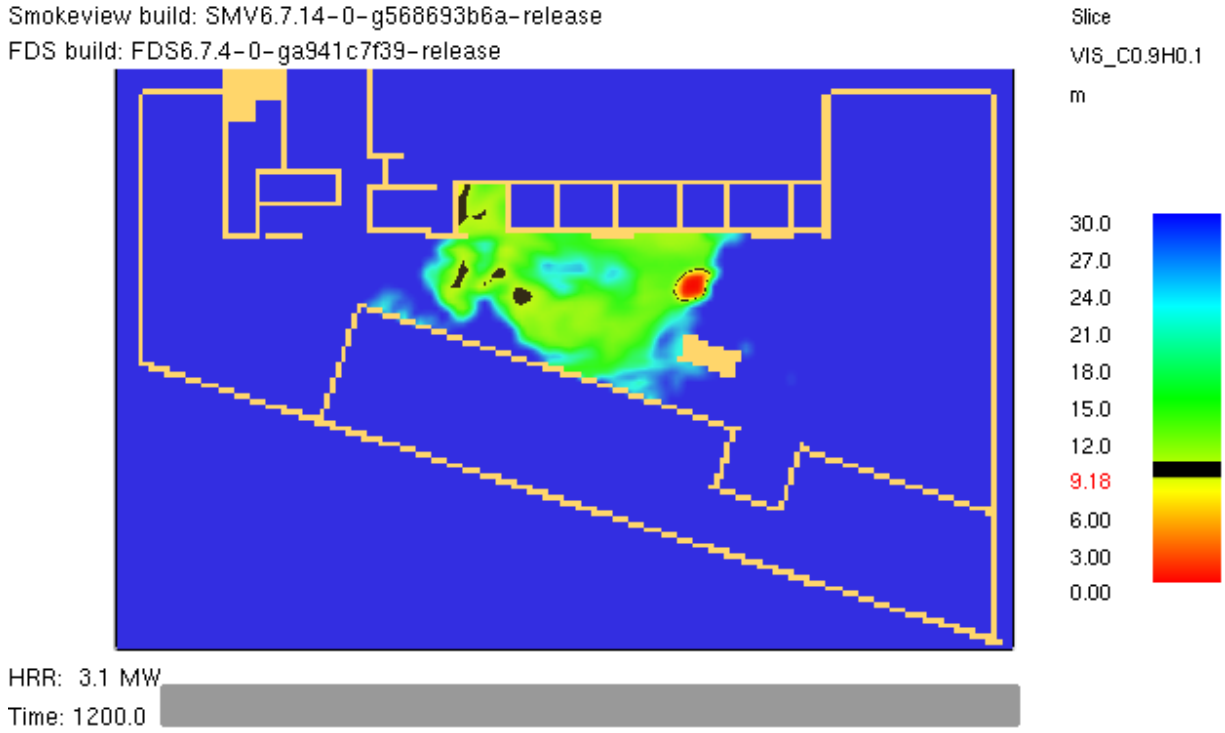
- Visibility Slice Files – The color bar scale on the right side is the legend for visibility in the slice file. The color varies from red (low visibility) to blue (high visibility). A contour line is included at a visibility distance of 9.1 meters (30 feet) indicating the point where tenability drops below the allowable threshold. Any areas on the red side of the contour line do not pass the visibility criterion.

  It should be recognized that localized losses of tenability are not a cause for a complete failure. The tenability must be lower than the threshold value of 9.1 meters (30 feet) for a distance of 30 feet to be a true failure.

- Temperature Slice Files – The color bar scale on the right side is the legend for temperatures in the slice file. The color varies from red (high temperature) to blue (low temperature). A contour line is included at a temperature of 60° C (140° F) indicating the point where tenability drops below the allowable threshold. Any areas on the red side of the contour line do not pass the temperature criterion.

Fire Scenario 1: Open Atrium Space Fire

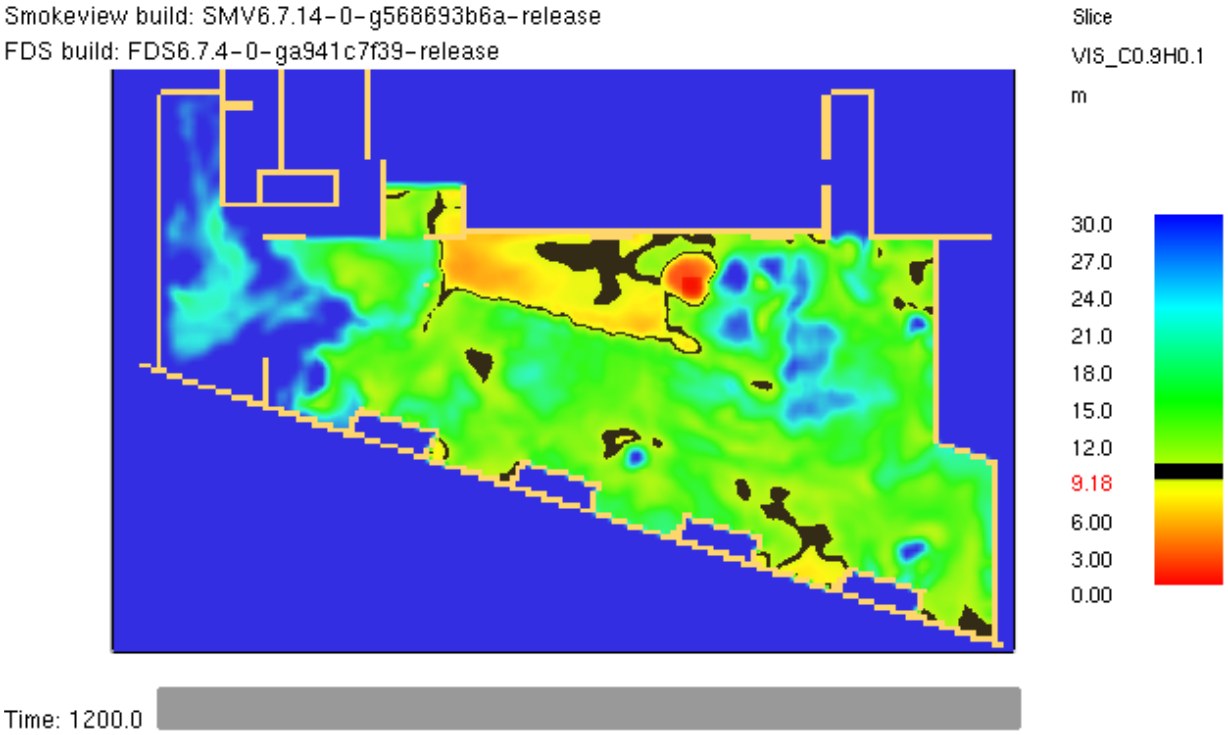
Level 1 – Visibility Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)



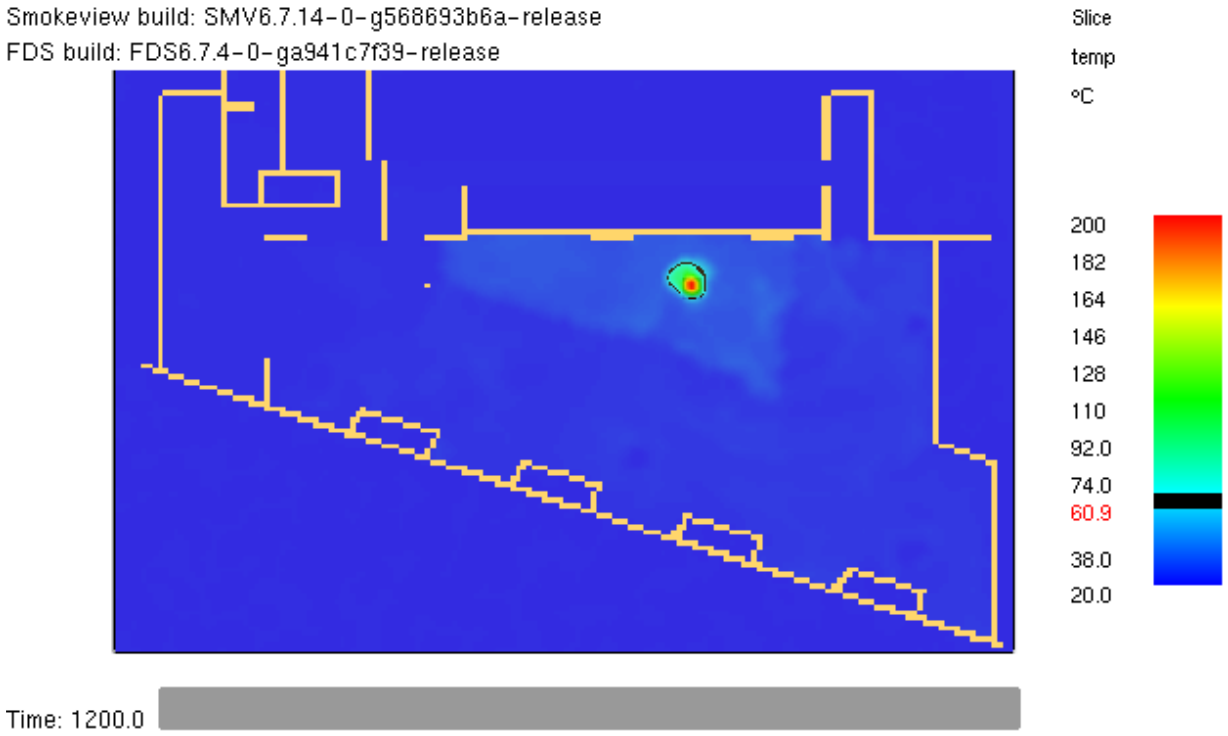
Level 1 – Temperature Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)

Fire Scenario 1: Open Atrium Space Fire

Level 2 – Visibility Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)



Level 2 – Temperature Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)



Fire Scenario 2: Reception Area Fire

Level 1 – Visibility Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)

Level 1 – Temperature Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)

Fire Scenario 1: Open Atrium Space Fire

Level 2 – Visibility Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)

Level 2 – Temperature Slice 6 ft Above Finished Floor at 20 Minutes (Steady state)