

**CLAYTON COUNTY WATER AUTHORITY  
MORROW, GA**



**PROJECT MANUAL**

**FOR**

**BID NUMBER: 2020-GS-08**

**WALNUT CREEK LIFT STATION**

**MAY 2020**

**ISSUED FOR CONSTRUCTION**

**VOLUME 2 OF 3  
DIVISIONS 02 – 46  
TECHNICAL SPECIFICATIONS**

**Hazen**



**VOLUME 1 OF 3**  
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**SECTION 02 41 00**  
**DEMOLITION**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish all labor, materials and equipment in accordance with the requirements of Section 01 14 00 – Coordination with Owner’s Operations.
- B. In addition, the Contractor shall demolish and remove all concrete and asphaltic paving, curbs, sidewalk, and miscellaneous yard structures as required and shown on the Contract Drawings during the construction work.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 14 00 – Coordination with Owner’s Operations
- B. Section 01 42 00 – References

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. References shall be in accordance with reference standards, codes, and specifications as set forth herein and in Section 31 10 00 – Clearing, Grubbing, and Site Preparation.

**PART 2 – EXECUTION**

**2.01 DEMOLITION**

- A. Existing concrete and asphaltic paving, curbs, sidewalk and miscellaneous yard structures within the areas designated for new construction work shall be completely demolished and all debris removed from the site.
- B. Excavation caused by demolition shall be backfilled with fill free from rubbish and debris.
- C. Work shall be performed in such manner as not to endanger the safety of the workmen or the public or cause damage to nearby structures.
- D. Provide all barriers and precautionary measures in accordance with Owner's requirements and other authorities having jurisdiction.
- E. Where parts of existing pavements or structures are to remain in service, demolish the portions to be removed, repair damage, and leave the pavement or structure in proper condition for the intended use. Remove asphalt or concrete pavement, concrete, and

masonry to the lines designated by saw-cutting, drilling, chipping, or other suitable methods. Leave the resulting surfaces reasonably true and even, with sharp straight corners that will result in neat joints with new construction and be satisfactory for the purpose intended. Where existing reinforcing rods are to extend into new construction, remove the concrete so that the reinforcing is clean and undamaged. Cut off other reinforcing 1/2-inch below the surface and fill with epoxy resin binder flush with the surface.

- F. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of the adjoining and/or nearby pavements and structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

## **2.02 DISPOSAL OF MATERIAL**

- A. All debris resulting from the demolition and removal work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed. All other material shall be disposed of off-site by the Contractor at his expense.
- B. Burning of any debris resulting from the demolition will not be permitted at the site.

## **PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

**SECTION 03 11 00**  
**CONCRETE FORMWORK**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Provide materials, labor, and equipment required for the design and construction of all concrete formwork, bracing, shoring and supports in accordance with the provisions of the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 21 00 – Reinforcing Steel
- B. Section 03 15 00 – Concrete Accessories
- C. Section 03 15 16 – Joints in Concrete
- D. Section 03 30 00 – Cast-in-Place Concrete

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. ACI 318 – Building Code Requirements for Structural Concrete
  - 3. ACI 301 – Specifications for Structural Concrete for Buildings
  - 4. ACI 347 – Recommended Practice for Concrete Formwork
  - 5. U.S. Product Standard for Concrete Forms, Class I, PS 1
  - 6. ACI 117 – Standard Specifications for Tolerances for Concrete Construction and Materials

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Manufacturer's data on proposed form release agent

2. Manufacturer's data on proposed formwork system including form ties

## **1.05 QUALITY ASSURANCE**

- A. Concrete formwork shall be in accordance with ACI 301, ACI 318, and ACI 347.

## **PART 2 – PRODUCTS**

### **2.01 FORMS AND FALSEWORK**

- A. All forms shall be smooth surface forms unless otherwise specified.
- B. Wood materials for concrete forms and falsework shall conform to the following requirements:
  1. Lumber for bracing, shoring, or supporting forms shall be Douglas Fir or Southern Pine, construction grade or better, in conformance with U.S. Product Standard PS20. All lumber used for forms, shoring or bracing shall be new material.
  2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Pine high density overlaid (HDO) plywood manufactured especially for concrete formwork and shall conform to the requirements of PS1 for Concrete Forms, Class I, and shall be edge sealed. Thickness shall be as required to support concrete at the rate it is placed, but not less than 5/8-inch thick.
- C. Other form materials such as metal, fiberglass, or other acceptable material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line and grade indicated may be submitted to the Engineer for approval, but only materials that will produce a smooth form finish equal or better than the wood materials specified will be considered.

### **2.02 FORMWORK ACCESSORIES**

- A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties, or of other removable form-tie fasteners having a circular cross-section, shall not exceed 7/8-inch, and all such fasteners shall be such as to leave holes of regular shape for reaming.
- B. Form ties for water-retaining structures shall have integral waterstops. Removable taper ties may be used when acceptable to the Engineer. A preformed mechanical EPDM rubber plug shall be used to seal the hole left after the removal of the taper tie. Plug shall be X-Plug by the Greenstreak Group, Inc., or approved equal. Friction fit plugs shall not be used.

- C. Form release agent shall be a blend of natural and synthetic chemicals that employs a chemical reaction to provide quick, easy and clean release of concrete from forms. It shall not stain the concrete and shall leave the concrete with a paintable surface. Formulation of the form release agent shall be such that it would minimize formation of "bug holes" in cast-in-place concrete.

## **PART 3 – EXECUTION**

### **3.01 FORM DESIGN**

- A. Forms and falsework shall be designed for total dead load, plus all construction live load as outlined in ACI 347. Design and engineering of formwork and safety considerations during construction shall be the responsibility of the Contractor.
- B. Forms shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. The maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members.
- C. All forms shall be designed for predetermined placing rates per hour, considering expected air temperatures and setting rates.

### **3.02 CONSTRUCTION**

- A. The type, size, quality, and strength of all materials from which forms are made shall be subject to the approval of the Engineer. No falsework or forms shall be used which are not clean and suitable. Deformed, broken or defective falsework and forms shall be removed from the work.
- B. Forms shall be smooth and free from surface irregularities. Suitable and effective means shall be provided on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Joints between the forms shall be sealed to eliminate any irregularities. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to a practical minimum.
- C. Forms shall be true to line and grade and shall be sufficiently rigid to prevent displacement and sagging between supports. Curved forms shall be used for curved and circular structures. Straight panels joined at angles will not be acceptable for forming curved structures. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly-placed concrete. Facing material shall be supported with studs or other backing which shall prevent both visible deflection marks in the concrete and deflections beyond the tolerances specified.

- D. Forms shall be mortar tight so as to prevent the loss of water, cement and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1 to 1-1/2 inch diameter polyethylene rod held in position to the underside of the wall form.
- E. All vertical surfaces of concrete members shall be formed, and side forms shall be provided for all footings, slab edges and grade beams, except where placement of the concrete against the ground is called for on the Drawings. Not less than 1-inch of concrete shall be added to the thickness of the concrete member as shown where concrete is permitted to be placed against trimmed ground in lieu of forms. Such permission will be granted only for members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.
- F. All forms shall be constructed in such a manner that they can be removed without hammering or prying against the concrete. Wood forms shall be constructed for wall openings to facilitate loosening and to counteract swelling of the forms.
- G. Adequate clean-out holes shall be provided at the bottom of each lift of forms. Temporary openings shall be provided at the base of column forms and wall forms and at other points to facilitate cleaning and observation immediately before the concrete is deposited. The size, number and location of such clean-outs shall be as acceptable to the Engineer.
- H. Construction joints shall not be permitted at locations other than those shown or specified, except as may be acceptable to the Engineer. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. For flush surfaces at construction joints exposed to view, the contact surface of the form sheathing over the hardened concrete in the previous placement shall be lapped by not more than 1 inch. Forms shall be held against hardened concrete to prevent offset or loss of mortar at construction joints and to maintain a true surface.
- I. The formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads. Set forms and intermediate screed strips for slabs accurately to produce the designated elevations and contours of the finished surface. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment. When formwork is cambered, set screeds to a like camber to maintain the proper concrete thickness.
- J. Positive means of adjustment (wedges or jacks) for shores and struts shall be provided and all settlement shall be taken up during concrete placing operation. Shores and struts shall be securely braced against lateral deflections. Wedges shall be fastened firmly in

place after final adjustment of forms prior to concrete placement. Formwork shall be anchored to shores or other supporting surfaces or members to prevent upward or lateral movement of any part of the formwork system during concrete placement. If adequate foundation for shores cannot be secured, trussed supports shall be provided.

- K. Runways shall be provided for moving equipment with struts or legs. Runways shall be supported directly on the formwork or structural member without resting on the reinforcing steel.

### **3.03 TOLERANCES**

- A. Unless otherwise indicated in the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in ACI 117.
- B. Structural framing of reinforced concrete around elevators and stairways shall be accurately plumbed and located within 1/4 in. tolerance from established dimensions.
- C. The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used for reference purposes to check tolerances. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by Contractor's personnel and by the Engineer and shall be in sufficient number and properly installed. During concrete placement, the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.
- D. Regardless of the tolerances specified, no portion of the building shall extend beyond the legal boundary of the building.

### **3.04 FORM ACCESSORIES**

- A. Suitable moldings shall be placed to bevel or round all exposed corners and edges of beams, columns, walls, slabs, and equipment pads. Chamfers shall be 3/4 inch unless otherwise noted.
- B. Form ties shall be so constructed that the ends, or end fasteners, can be removed without causing appreciable spalling at the faces of the concrete. After ends, or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than 2 inches from the formed face of the concrete that is exposed to water or enclosed surfaces above the water surface, and not less than 1 inch from the formed face of all other concrete. Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar as specified in Section 03 35 00 – Concrete Finishes. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete member. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal will not be permitted. No snap ties

shall be broken off until the concrete is at least three days old. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste.

### **3.05 APPLICATION – FORM RELEASE AGENT**

- A. Forms for concrete surfaces that will not be subsequently waterproofed shall be coated with a form release agent. Form release agent shall be applied on formwork in accordance with manufacturer's recommendations.

### **3.06 INSERTS AND EMBEDDED ITEMS**

- A. Sleeves, pipe stubs, inserts, anchors, expansion joint material, waterstops, and other embedded items shall be positioned accurately and supported against displacement prior to concreting. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

### **3.07 FORM CLEANING AND REUSE**

- A. The inner faces of all forms shall be thoroughly cleaned prior to concreting. Forms may be reused only if in good condition and only if acceptable to the Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture. Unused tie rod holes in forms shall be covered with metal caps or shall be filled by other methods acceptable to the Engineer.

### **3.08 FORM REMOVAL AND SHORING**

- A. Forms shall not be disturbed until the concrete has attained sufficient strength. Sufficient strength shall be demonstrated by structural analysis considering proposed loads, strength of forming and shoring system, and concrete strength data. Shoring shall not be removed until the supported member has acquired sufficient strength to support its weight and the load upon it. Members subject to additional loads during construction shall be adequately shored to sustain all resulting stresses. Forms shall be removed in such manner as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.
- B. Provided the strength requirements specified above have been met and subject to the Engineer's approval, forms may be removed at the following minimum times. The Contractor shall assume full responsibility for the strength of all such components from which forms are removed prior to the concrete attaining its full design compressive strength. Shoring may be required at the option of the Engineer beyond these periods.



**Ambient Temperature (°F.) During Concrete Placement**

	<b>Over 95°</b>	<b>70°-95°</b>	<b>60°-70°</b>	<b>50°-60°</b>	<b>Below 50°</b>
Walls	5 days	2 days	2 days	3 days	Do not remove until directed by Engineer (7 days minimum)
Columns	7 days	2 days	3 days	4 days	
Beam Soffits	10 days	7 days	7 days	7 days	
Elevated Slabs	12 days	7 days	7 days	7 days	

- C. When, in the opinion of the Engineer, conditions of the work or weather justify, forms may be required to remain in place for longer periods of time.
- D. An accurate record shall be maintained by the Contractor of the dates of concrete placings and the exact location thereof and the dates of removal of forms. These records shall be available for inspection at all times at the site, and two copies shall be furnished the Engineer upon completion of the concrete work.

**3.09 RESHORING**

- A. When reshoring is permitted or required the operations shall be planned in advance and subjected to approval by the Engineer.
- B. Reshores shall be placed after stripping operations are complete but in no case later than the end of the working day on which stripping occurs.
- C. Reshoring for the purpose of early form removal shall be performed so that at no time will large areas of new construction be required to support their own weight. While reshoring is under way, no construction or live loads shall be permitted on the new construction. Reshores shall be tightened to carry their required loads but they shall not be overtightened so that the new construction is overstressed. Reshores shall remain in place until the concrete has reached its specified 28-day strength, unless otherwise specified.
- D. For floors supporting shores under newly placed concrete, the original supporting shores shall remain in place or reshores shall be placed. The shoring or reshoring system shall have a capacity sufficient to resist the anticipated loads and, in all cases, shall have a capacity equal to at least one-half of the capacity of the shoring system above. Reshores shall be located directly under a reshore position above unless other locations are permitted.

- E. In multi-story buildings, reshoring shall extend over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads so the design superimposed loads of the floors supporting shores are not exceeded.

**END OF SECTION**

**SECTION 03 15 00**  
**CONCRETE ACCESSORIES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all materials, labor and equipment required to provide all concrete accessories including waterstops, expansion joint material, joint sealants, expansion joint seals, contraction joint inserts, and epoxy bonding agent.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 15 16 – Joints in Concrete
- C. Section 03 30 00 – Cast-in-Place Concrete
- D. Section 07 90 00 – Joint Fillers, Sealants, and Caulking

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
  - 2. ASTM D412 – Standard Tests for Rubber Properties in Tension
  - 3. ASTM D 624 – Standard Test method for Rubber Property - Tear Resistance
  - 4. ASTM D 638 – Standard Test Method for Tensile Properties of Plastics
  - 5. ASTM D1751 – Standard Specifications for Preformed Expansion Joint fillers for Concrete Paving and Structural Construction (nonextruding and resilient bituminous types)
  - 6. ASTM D 1752 – Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
  - 7. ASTM D 1171 – Standard Test Method for Ozone Resistance at 500 pphm

8. ASTM D 471 – Standard Test Method for Rubber Properties

#### **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  1. Manufacturer's literature on all products specified herein including material certifications.
  2. Proposed system for supporting PVC waterstops in position during concrete placement.
  3. Samples of products if requested by the Engineer.

### **PART 2 – PRODUCTS**

#### **2.01 POLYVINYL CHLORIDE (PVC) WATERSTOPS**

- A. PVC waterstops for construction joints shall be flat ribbed type, 6 inches wide with a minimum thickness at any point of 3/8 inches.
- B. Waterstops for expansion joints shall be ribbed with a center bulb. They shall be 9 inches wide with a minimum thickness at any point of 3/8 inch unless shown or specified otherwise. The center bulb shall have a minimum outside diameter of 1 inch and a minimum inside diameter of 1/2 inch.
- C. The waterstops shall be manufactured from virgin polyvinyl chloride plastic compound and shall not contain any scrap or reclaimed material or pigment whatsoever. The properties of the polyvinyl chloride compound used, as well as the physical properties of the waterstops, shall exceed the requirements of the U.S. Army Corps. of Engineers' Specification CRD-C572. The waterstop material shall have an off-white, milky color.
- D. The required minimum physical characteristics for this material are:
  1. Tensile strength – 1,750 psi (ASTM D-638).
  2. Ultimate elongation – not less than 280% (ASTM D-638).
- E. No reclaimed PVC shall be used for the manufacturing of the waterstops. The Contractor shall furnish certification that the proposed waterstops meet the above requirements.
- F. PVC waterstops shall be as manufactured by BoMetals, Inc., DuraJoint Concrete Accessories, or Sika Greenstreak.
- G. All waterstop intersections, both vertical and horizontal, shall be made from factory fabricated corners and transitions. Only straight butt joint splices shall be made in field.

## **2.02 RETROFIT WATERSTOPS**

- A. Retrofit waterstops shall be used where specifically shown on Drawings for sealing joints between existing concrete construction and new construction.
- B. Retrofit waterstops shall be PVC waterstops fabricated from material as described in Section 2.01 of this Specification.
- C. Retrofit waterstop shall be attached to existing concrete surface as shown on Drawings.
- D. Use of split waterstop in lieu of specially fabricated retrofit waterstop will not be acceptable.
- E. E. Retrofit Waterstop manufacturer must provide a complete system including all Waterstop, stainless steel anchoring hardware, and epoxy for installation.
- F. For construction joints, retrofit waterstop shall be style number 609 by Sika Greenstreak, RF-638 by BoMetals, Inc., or approved equal. For expansion joints, retrofit waterstop shall be style number 667 by Sika Greenstreak, RF-912 by BoMetals, Inc., Type 36RT Retrofit Kit by DuraJoint Concrete Accessories, or approved equal.

## **2.03 CHEMICAL RESISTANT WATERSTOPS**

- A. Where specifically noted on Contract Drawings, chemical resistant waterstops shall be used instead of PVC waterstops.
- B. Chemical resistant waterstops for construction joints shall be ribbed with a center bulb. They shall be 6 inches wide with a minimum thickness at any point of 3/16 inches.
- C. Chemical resistant waterstops for expansion joints shall be ribbed tear web. They shall be 9 inches wide with a tear web designed to accommodate 1 inch of free movement minimum.
- D. Chemical resistant retrofit waterstop shall be a minimum of 2½" wide along the ribbed side and a minimum 5" wide along the side attached to the existing concrete surface. Retrofit waterstop shall include a centerbulb and shall have a minimum thickness of 3/16". Retrofit waterstop manufacturer shall provide a complete system including waterstop, stainless steel anchoring hardware and epoxy for installation.
- E. Chemical resistant waterstops shall be manufactured from a fully crosslinked thermoplastic vulcanizate rubber.
- F. Waterstops shall be TPER by BoMetals, Inc., Earth Shield TPV/TPE-R by JP Specialties, Inc., Westec TPER by Westec Barrier Technologies, or TPE-R by DuraJoint Concrete Accessories.

## **2.04 WATERPROOF MEMBRANE PATCH**

- A. Waterproof membrane patch shall be Sikadur Combiflex by Sika Corporation or approved equal. Minimum width of waterstop material shall be twelve (12) inches unless shown otherwise on Contract Drawings.

## **2.05 EXPANDING RUBBER WATERSTOP**

- A. Expanding rubber shall be designed to expand under hydrostatic conditions. Waterstops shall be Adeka Ultra Seal MC-2010MN by Adeka Ultra Seal/OCM, Inc., or Hydrotite CJ-1020-2K by Sika Greenstreak, for concrete thickness greater than nine inches. For thicknesses less than nine inches, Adeka Ultra Seal KBA-1510FP or Hydrotite CJ-1020-2K shall be used.
- B. Waterstop shall be a chemically modified natural rubber product with a hydrophilic agent.
- C. Waterstop has a stainless steel mesh or coextrusion of non-hydrophilic rubber to direct expansion in the thickness direction and restrict the expansion in the longitudinal direction.

## **2.06 WATERSTOP ADHESIVE**

- A. Adhesive between waterstops and existing concrete shall be Neoprene Adhesive 77-198 by JGF Adhesives, Sikadur 31 Hi-Mod Gel by Sika Corporation, DP-605 NS Urethane Adhesive by 3M Adhesive Systems.
- B. Hydrophilic, non-bentonite water swelling elastic sealant shall be used to bond expanding rubber waterstops to rough surfaces. Hydrophilic elastic sealant shall be P-201 by Adeka Ultra Seal/OCM, Inc., Leakmaster LV-1 by Sika Greenstreak, or approved equal.

## **2.07 JOINT SEALANTS**

- A. Joint sealants shall comply with Section 07 90 00 – Joint Fillers, Sealants, and Caulking.

## **2.08 EXPANSION JOINT MATERIAL**

- A. Preformed expansion joint material shall be non-extruding, and shall be of the following types:
  - 1. Type I – Sponge rubber, conforming to ASTM D1752, Type I.
  - 2. Type II – Cork, conforming to ASTM D1752, Type II.
  - 3. Type III – Self-expanding cork, conforming to ASTM D1752, Type III.
  - 4. Type IV – Bituminous fiber, conforming to ASTM Designation D1751.

## **2.09 EXPANSION JOINT SEAL**

- A. Expansion Joint Seal System shall consist of a preformed neoprene profile, installed using the same dimensions as the joint gap, bonded with a two-component epoxy adhesive and pressurized during the adhesive cure time.
- B. The expansion joint system shall be Hydrozo/Jeene Structural Sealing joint system by Hydrozo/Jeene, Inc.

## **2.10 CONTRACTION JOINT INSERTS**

- A. Contraction joint inserts shall be Zip-Cap by Greenstreak Plastic Products, Zip-Joint by BoMetals, Inc. control joint formers.

## **2.11 EPOXY BONDING AGENT**

- A. Epoxy bonding agent shall conform to ASTM C881 and shall be Sikadur 32 Hi-Mod, Sika Corporation, Lyndhurst, N.J.; Euco #452 Epoxy System, Euclid Chemical Company, Cleveland, OH, MasterInject 1500 by BASF Master Builder Solutions (BASF).

## **2.12 EPOXY RESIN BINDER**

- A. Epoxy resin binder shall conform to the requirements of ASTM C-881, Type III, Grade 3, Class B and C for epoxy resin binder and shall be Sikadur 23, Low-Mod-Gel, manufactured by the Sika Corporation, Lyndhurst, N.J., Flexocrete Gel manufactured by DuraJoint Concrete Accessories or Euco #352 Gel, Euclid Chemical Company, MasterEmaco ADH 327 or 327 RS by BASF Master Builder Solutions.

## **PART 3 – EXECUTION**

### **3.01 PVC AND CHEMICAL RESISTANT WATERSTOPS**

- A. PVC and chemical resistant waterstops shall be provided in all construction and expansion joints in water bearing structures and at other such locations as required by the Drawings.
- B. Waterstops shall be carefully positioned so that they are embedded to an equal depth in concrete on both sides of the joint. They shall be kept free from oil, grease, mortar or other foreign matter. To ensure proper placement, all waterstops shall be secured in correct position at 12" on center along the length of the waterstop on each side, prior to placing concrete. Such method of support shall be submitted to the Engineer for review and approval. Grommets or small pre-punched holes as close to the edges as possible will be acceptable for securing waterstops.

- C. Splices in PVC waterstops and chemical resistant waterstops shall be made with a thermostatically controlled heating element. Only straight butt joint splices will be allowed in the field. Factory fabricated corners and transitions shall be used at all intersections. Splices shall be made in strict accordance with the manufacturer's recommended instructions and procedures. At least three satisfactory sample splices shall be made on the site. The Engineer may require tests on these splices by an approved laboratory. The splices shall exhibit not less than 80 percent of the strength of the unspliced material.
- D. All splices in waterstops will be subject to rigid review for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, discoloration, charring, and other defects which would reduce the potential resistance of the material to water pressure at any point. All defective joints shall be replaced with material which will pass said review and all faulty material shall be removed from the site and disposed of by the Contractor at no additional cost to the Owner.
- E. Retrofit waterstops shall be installed as shown on Contract Drawings using approved waterstop adhesive and Type 316 stainless steel batten bars and expansion anchors.
- F. Waterstop installation and splicing defects which are unacceptable include, but are not limited to the following:
  - 1. Tensile strength not less than 80 percent of parent material.
  - 2. Overlapped (not spliced) Waterstop.
  - 3. Misalignment of Waterstop geometry at any point greater than 1/16 inch.
  - 4. Visible porosity or charred or burnt material in weld area.
  - 5. Visible signs of splice separation when splice (24 hours or greater) is bent by hand at sharp angle.

### **3.02 WATERPROOF MEMBRANE PATCH AND EXPANDING RUBBER WATERSTOPS**

- A. Patches and waterstops shall be installed only where shown on the Drawings.
- B. Patches and waterstops shall be installed in strict accordance with manufacturer's recommendations.

### **3.03 WATERSTOP ADHESIVE**

- A. Adhesive shall be applied to both contact surfaces in strict accordance with manufacturer's recommendations.
- B. Adhesive shall be used where waterstops are attached to existing concrete surfaces.



### **3.04 INSTALLATION OF EXPANSION JOINT MATERIAL AND SEALANTS**

- A. Type I, II, or III shall be used in all expansion joints in structures and concrete pavements unless specifically shown otherwise on the Drawings. Type IV shall be used in sidewalk and curbing and other locations specifically shown on the Drawings.
- B. All expansion joints exposed in the finish work, exterior and interior, shall be sealed with the specified joint sealant. Expansion joint material and sealants shall be installed in accordance with manufacturer's recommended procedures and as shown on the Drawings.
- C. Expansion joint material that will be exposed after removal of forms shall be cut and trimmed to ensure a neat appearance and shall completely fill the joint except for the space required for the sealant. The material shall be held securely in place and no concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.
- D. A bond breaker shall be used between expansion joint material and sealant. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surfaces shall present a clean and even appearance.
- E. Type 1 joint sealant shall be used in all expansion and contraction joints in concrete, except where Type 7 or Type 8 is required as stated below, and wherever else specified or shown on the Drawings. It shall be furnished in pour grade or gun grade depending on installation requirements. Primers shall be used as required by the manufacturer. The sealant shall be furnished in colors as directed by the Engineer.
- F. Type 8 joint sealant shall be used in all concrete pavements and floors subject to heavy traffic and wherever else specified or shown on the Drawings.
- G. Type 7 joint sealant shall be used for all joints in chlorine contact tanks and wherever specified or shown on the Drawings.

### **3.05 EXPANSION JOINT SEAL**

- A. The expansion joint seal system shall be installed as shown on the Drawings in strict accordance with the manufacturer's recommendations.

### **3.06 CONTRACTION JOINT INSERTS**

- A. For contraction joints in slabs, inserts shall be floated in fresh concrete during finishing.
- B. For contraction joints in walls, inserts shall be secured in place prior to casting wall.

- C. Inserts shall be installed true to line at the locations of all contraction joints as shown on the Drawings.
- D. Inserts shall extend into concrete sufficient depth as indicated on the Drawings or specified in Section 03 15 16 – Joints in Concrete.
- E. Inserts shall not be removed from concrete until concrete has cured sufficiently to prevent chipping or spalling of joint edges due to inadequate concrete strength.

### **3.07 EPOXY BONDING AGENT**

- A. The Contractor shall use an epoxy bonding agent for bonding fresh concrete to existing concrete as shown on the Drawings.
- B. Bonding surface shall be clean, sound and free of all dust, laitance, grease, form release agents, curing compounds, and any other foreign particles.
- C. Application of bonding agent shall be in strict accordance with manufacturer's recommendations.
- D. Fresh concrete shall not be placed against existing concrete if epoxy bonding agent has lost its tackiness.

### **3.08 EPOXY RESIN BINDER**

- A. Epoxy resin binder shall be used to seal all existing rebar cut and burned off during demolition operations. Exposed rebar shall be burned back 1/2-inch minimum into existing concrete and the resulting void filled with epoxy resin binder.

**END OF SECTION**

**SECTION 03 15 16**  
**JOINTS IN CONCRETE**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENTS**

- A. Provide all materials, labor and equipment required for the construction of all joints in concrete specified herein and shown on the Drawings.
- B. Types of joints in concrete shall be as follows:
  - 1. Construction Joints - Joints between adjacent concrete placements continuously connected with reinforcement.
  - 2. Expansion Joints - Joints in concrete which allow thermal expansion and contraction of concrete. Reinforcement terminates within concrete on each side of joint.
  - 3. Contraction Joints - Joints formed in concrete to provide a weakened plane in concrete section to control formation of shrinkage cracks.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 15 00 – Concrete Accessories
- C. Section 03 30 00 – Cast-in-Place Concrete
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. ACI 301 – Specifications for Structural Concrete for Buildings
  - 2. ACI 318 – Building Code Requirements for Structural Concrete
  - 3. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures
  - 4. ACI 224.3 – Joints in Concrete Construction

## **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Layout drawings showing location and type of all joints to be placed in each structure.
  - 2. Details of proposed joints in each structure.
  - 3. For sawcut contraction joints submit documentation indicating the following:
    - a. Proposed method of sawcutting indicating early entry or conventional sawing.
    - b. Description of how work is to be performed including equipment to be utilized, size of crew performing the work and curing methods.
    - c. Description of alternate method in case of time constraint issues or failure of equipment.

## **PART 2 – MATERIALS**

### **2.01 MATERIALS**

- A. All materials required for joint construction shall comply with Section 03 15 00 - Concrete Accessories, and Section 07 90 00 – Joint Fillers, Sealants and Caulking.

## **PART 3 – EXECUTION**

### **3.01 CONSTRUCTION JOINTS**

- A. Construction joints shall be as shown on the Drawings. Otherwise, Contractor shall submit description of the joint and its location to Engineer for approval.
- B. Unless noted otherwise on the Drawings, construction joints shall be located near the middle of the spans of slabs, beams, and girders unless a beam intersects a girder at this point. In this case, the joints in the girders shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and the top of footings or floor slabs unless noted otherwise on Drawings. Beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.
- C. Maximum distance between horizontal joints in slabs and vertical joints in walls shall be 45'-0". For exposed walls with fluid or earth on the opposite side, the spacing between vertical and horizontal joints shall be a maximum of 25'-0".

- D. All corners shall be part of a continuous placement, and should a construction joint be required, the joint shall not be located closer than five feet from a corner.
- E. All reinforcing steel and welded wire fabric shall be continued across construction joints. Keys and inclined dowels shall be provided as shown on the Drawings or as directed by the Engineer. Longitudinal keys shall be provided in all joints in walls and between walls and slabs or footings, except as specifically noted otherwise on the Drawings. Size of keys shall be as shown on the Drawings.
- F. All joints in water bearing structures shall have a waterstop. All joints below grade in walls or slabs which enclose an accessible area shall have a waterstop.

### **3.02 EXPANSION JOINTS**

- A. Size and location of expansion joints shall be as shown on the Drawings.
- B. All expansion joints in water-bearing structures shall have a center-bulb type waterstop. All expansion joints below grade in walls or slabs which enclose an accessible area shall have a center-bulb type waterstop. Waterstop shall be as shown on Drawings and specified in Section 03 15 00, Concrete Accessories.

### **3.03 CONTRACTION JOINTS**

- A. Location of contraction joints shall be as shown on the Drawings.
- B. Contraction joints shall be formed either by sawcutting or with contraction joint inserts as specified in Section 03 15 00 – Concrete Accessories. Sawcutting of joints will not be permitted unless specifically approved by the Engineer.
- C. If approved by the Engineer, sawcutting of contraction joints in lieu of forming shall conform to the following requirements:
  - 1. Joints shall be sawed as soon as the concrete can support foot traffic without leaving any impression, normally the same day as concrete is placed and in no case longer than 24 hours after concrete is placed.
  - 2. Curing shall be performed using wet curing methods as indicated in Section 03 39 00 – Concrete Curing. Curing mats, fabrics or sheeting materials shall remain in place to the extent possible while cutting of joint is being performed. Curing materials shall only be removed as required and shall be immediately reinstalled once cutting of the joint has been completed.
  - 3. Depth of joint shall be as shown on the drawings or noted in these specifications. At locations where the joint cannot be installed to full depth due to curbs or other stopping points hand tools shall be used to complete joints.

4. Saw cut joints shall meet the requirements of ACI 224.3, Section 2.8, Jointing Practice.
- D. Unless noted otherwise on Drawings, depth of contraction joints shall be 1-1/2 inches in reinforced concrete and 1/3 of concrete thickness in unreinforced concrete.

### **3.04 JOINT PREPARATION**

- A. No concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.
- B. The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed by wire brushing, air or light sand blasting.
- C. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surface shall present a clean and even appearance.
- D. All joints shall be sealed as shown on the Drawings and specified in Section 03 15 00 – Concrete Accessories.

**END OF SECTION**

**SECTION 03 21 00**  
**REINFORCING STEEL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENTS**

- A. Provide all concrete reinforcing including all cutting, bending, fastening and any special work necessary to hold the reinforcing steel in place and protect it from injury and corrosion in accordance with the requirements of this section.
- B. Provide deformed reinforcing bars to be grouted into reinforced concrete masonry walls.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 23 00 – Stressing Tendons
- C. Section 03 15 00 – Concrete Accessories
- D. Section 03 30 00 – Cast-in-Place Concrete
- E. Section 03 40 00 – Precast Concrete

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. CRSI - Concrete Reinforcing Institute Manual of Standard Practice
  - 3. ACI SP66 - ACI Detailing Manual
  - 4. ACI 315 - Details and Detailing of Concrete Reinforcing
  - 5. ACI 318 - Building Code Requirements for Structural Concrete
  - 6. ICC-ES AC193 - Acceptance Criteria for Expansion and Screw Anchors (Concrete)
  - 7. WRI - Manual of Standard Practice for Welded Wire Fabric

8. ASTM A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcing
9. ASTM A 1064 - Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

#### **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  1. Detailed placing and shop fabricating drawings, prepared in accordance with ACI 315 and ACI Detailing Manual - (SP66), shall be furnished for all concrete reinforcing. These drawings shall be made to such a scale as to clearly show joint locations, openings, and the arrangement, spacing and splicing of the bars.
  2. Mill test certificates - 3 copies of each.
  3. Description of the reinforcing steel manufacturer's marking pattern.
  4. Requests to relocate any bars that cause interferences or that cause placing tolerances to be violated.
  5. Proposed supports for each type of reinforcing.
  6. Request to use splices not shown on the Drawings.
  7. Request to use mechanical couplers along with manufacturer's literature on mechanical couplers with instructions for installation, and certified test reports on the couplers' capacity.
  8. Request for placement of column dowels without the use of templates.
  9. Request and procedure to field bend or straighten partially embedded reinforcing.
  10. International Code Council–Evaluation Services Report (ICC-ES ESR) for dowel adhesives.
  11. Certification that all installers of dowel adhesive are certified as Adhesive Anchor Installers in accordance with the ACI-CRSI Anchor Installer Certification Program.
  12. Adhesive dowel testing plan.

#### **1.05 QUALITY ASSURANCE**

- A. If requested by the Engineer, the Contractor shall provide samples from each load of reinforcing steel delivered in a quantity adequate for testing. Costs of initial tests will be paid by the Owner. Costs of additional tests due to material failing initial tests shall be paid by the Contractor.



- B. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information.
- C. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards for all installers who will be installing adhesive anchors in the horizontal to vertically overhead orientation.
- D. Special inspections for adhesive dowels shall be conducted in accordance with the manufacturer's instructions and Specification Section 01 45 33 – Special Inspections. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

## **PART 2 – PRODUCTS**

### **2.01 REINFORCING STEEL**

- A. Bar reinforcing shall conform to the requirements of ASTM A 615 for Grade 60 Billet Steel reinforcing. All reinforcing steel shall be from domestic mills and shall have the manufacturer's mill marking rolled into the bar which shall indicate the producer, size, type and grade. All reinforcing bars shall be deformed bars. Smooth reinforcing bars shall not be used unless specifically called for on Drawings.
- B. Welded wire fabric reinforcing shall conform to the requirements of ASTM A 1064 and the details shown on the Drawings.
- C. A certified copy of the mill test on each load of reinforcing steel delivered showing physical and chemical analysis shall be provided, prior to shipment. The Engineer reserves the right to require the Contractor to obtain separate test results from an independent testing laboratory in the event of any questionable steel. When such tests are necessary because of failure to comply with this Specification, such as improper identification, the cost of such tests shall be borne by the Contractor.
- D. Field welding of reinforcing steel will not be allowed.
- E. Use of coiled reinforcing steel will not be allowed.

### **2.02 ACCESSORIES**

- A. Accessories shall include all necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers and other devices to position reinforcing during concrete placement. Wire bar supports shall be plastic protected (CRSI Class 1).

- B. Concrete blocks (dobies), used to support and position bottom reinforcing steel, shall have the same or higher compressive strength as specified for the concrete in which it is located.

### **2.03 MECHANICAL COUPLERS**

- A. Mechanical couplers shall develop a tensile strength which exceeds 100 percent of the ultimate tensile strength and 125 percent of the yield strength of the reinforcing bars being spliced. The reinforcing steel and coupler used shall be compatible for obtaining the required strength of the connection.
- B. Where the type of coupler used is composed of more than one component, all components required for a complete splice shall be supplied.
- C. Hot forged sleeve type couplers shall not be used. Acceptable mechanical couplers are Dayton Superior Dowel Bar Splicer System by Dayton Superior, Dayton, Ohio, or approved equal. Mechanical couplers shall only be used where shown on the Drawings or where specifically approved by the Engineer.
- D. Where the threaded rebar to be inserted into the coupler reduces the diameter of the bar, the threaded rebar piece shall be provided by the coupler manufacturer.

### **2.04 DOWEL ADHESIVE SYSTEM**

- A. Where shown on the Drawings, reinforcing bars anchored into hardened concrete with a dowel adhesive system shall use a two-component adhesive mix which shall be injected with a static mixing nozzle following manufacturer's instructions.
- B. All holes shall be drilled in accordance with the manufacturer's instructions except that core drilled holes shall not be permitted unless specifically allowed by the Engineer. Cored holes, if allowed by the manufacturer and approved by the Engineer, shall be roughened in accordance with manufacturer's requirements.
- C. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with manufacturer's instructions prior to installation of adhesive and reinforcing bar.
- D. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer.
- E. Injection of adhesive into the hole shall be performed in a manner to minimize the formation of air pockets in accordance with the manufacturer's instructions.
- F. Embedment Depth:

1. The embedment depth of the bar shall be as shown on the Drawings. Although all manufacturers listed below are permitted, the embedment depth shown on the Drawings is based on "Pure 110+" by DeWalt" ESR 3298 issued 7/2016. If the Contractor submits one of the other named dowel adhesives from the list below, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.
  2. Where the embedment depth is not shown on the Drawings, the embedment depth shall be determined to provide the minimum allowable bond strength equal to the tensile strength of the rebar according to the manufacturer's ICC-ES ESR.
  3. The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long term temperature of 110 degrees F, and maximum short term temperature of 140 degrees F. In no case shall the embedment depth be less than the minimum, or more than the maximum, embedment depths stated in the manufacturer's ICC-ES ESR.
- G. Engineer's approval is required for use of this system in locations other than those shown on the Drawings.
- H. The adhesive system shall be IBC compliant for use in both cracked and uncracked concrete in all Seismic Design Categories and shall be "Epcon C6+ Adhesive Anchoring System" as manufactured by ITW Redhead, " HIT-HY 200 Adhesive Anchoring System" as manufactured by Hilti, Inc. "SET-XP Epoxy Adhesive Anchors" as manufactured by Simpson Strong-Tie Co. or "Pure 110+ Epoxy Adhesive Anchor System" by DeWalt. Fast-set epoxy formulations shall not be acceptable. No or equal products will be considered, unless pre-qualified and approved.
- I. All individuals installing dowel adhesive system shall be certified as an Adhesive Anchor Installer in accordance with the ACI-CRSI Anchor Installation Certification Program.

## **PART 3 – EXECUTION**

### **3.01 TEMPERATURE REINFORCING**

- A. Unless otherwise shown on the Drawings or in the absence of the concrete reinforcing being shown, the minimum cross sectional area of horizontal and vertical concrete reinforcing in walls shall be 0.0033 times the gross concrete area and the minimum cross sectional area of reinforcing perpendicular to the principal reinforcing in slabs shall be 0.0020 times the gross concrete area. Temperature reinforcing shall not be spaced further apart than five times the slab or wall thickness, nor more than 18 inches.

### **3.02 FABRICATION**

- A. Reinforcing steel shall be accurately formed to the dimensions and shapes shown on the Drawings and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings.
- B. The Contractor shall fabricate reinforcing bars for structures in accordance with the bending diagrams, placing lists and placing Drawings.
- C. No fabrication shall commence until approval of Shop Drawings has been obtained. All reinforcing bars shall be shop fabricated unless approved to be bent in the field. Reinforcing bars shall not be straightened or rebent in a manner that will injure the material. Heating of bars will not be permitted.
- D. Welded wire fabric with longitudinal wire of W9.5 size or smaller shall be either furnished in flat sheets or in rolls with a core diameter of not less than 10 inches. Welded wire fabric with longitudinal wires larger than W9.5 size shall be furnished in flat sheets only.

### **3.03 DELIVERY, STORAGE AND HANDLING**

- A. All reinforcing shall be neatly bundled and tagged for placement when delivered to the job site. Bundles shall be properly identified for coordination with mill test reports.
- B. Reinforcing steel shall be stored above ground on platforms or other supports and shall be protected from the weather at all times by suitable covering. It shall be stored in an orderly manner and plainly marked to facilitate identification.
- C. Reinforcing steel shall at all times be protected from conditions conducive to corrosion until concrete is placed around it.
- D. The surfaces of all reinforcing steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcing shall be reinspected and if necessary recleaned.

### **3.04 PLACING**

- A. Reinforcing steel shall be accurately positioned as shown on the Drawings and shall be supported and wired together to prevent displacement, using annealed iron wire ties or suitable clips at intersections. All reinforcing steel shall be supported by concrete, plastic or plastic protected (CRSI Class 1) metal supports, spacers or metal hangers which are strong and rigid enough to prevent any displacement of the reinforcing steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the reinforcing bars without settlement. In no case shall concrete block supports be continuous.

- B. The portions of all accessories in contact with the formwork shall be made of plastic or steel coated with a 1/8 inch minimum thickness of plastic which extends at least 1/2 inch from the concrete surface. Plastic shall be gray in color.
- C. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage.
- D. Reinforcing bars additional to those shown on the Drawings, which may be found necessary or desirable by the Contractor for the purpose of securing reinforcing in position, shall be provided by the Contractor at no additional cost to the Owner.
- E. Reinforcing placing, spacing, and protection tolerances shall be within the limits specified in ACI 318 except where in conflict with the Building Code, unless otherwise specified.
- F. Reinforcing bars may be moved within one bar diameter as necessary to avoid interference with other concrete reinforcing, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed placing tolerances, the resulting arrangement of bars shall be as acceptable to the Engineer.
- G. Welded wire fabric shall be supported on slab bolsters spaced not less than 30 inches on centers, extending continuously across the entire width of the reinforcing mat and supporting the reinforcing mat in the plane shown on the Drawings.
- H. Reinforcing shall not be straightened or rebent unless specifically shown on the drawings. Bars with kinks or bends not shown on the Drawings shall not be used. Coiled reinforcement shall not be used.
- I. Dowel Adhesive System shall be installed in strict conformance with the manufacturer's recommendations and as required in Article 2.04 above. A representative of the manufacturer must be on site prior to adhesive dowel installation to provide instruction on proper installation procedures for all adhesive dowel installers. Testing of adhesive dowels shall be as indicated below. If the dowels have a hook at the end to be embedded in subsequent work, an approved mechanical coupler shall be provided at a convenient distance from the face of existing concrete to facilitate adhesive dowel testing while maintaining required hook embedment in subsequent work.
- J. All adhesive dowel installations in the horizontal or overhead orientation shall be conducted by a certified Adhesive Anchor Installer as certified by ACI/CSRI per ACI 318-11 9.2.2. Current AAI Certification must be submitted to the Engineer of Record for approval prior to commencement of any adhesive anchor installations.
- K. Adhesive Dowel Testing
  - 1. At all locations where adhesive dowels are shown on the Drawings, at least 10 percent of all adhesive dowels installed shall be tested to the value indicated on the Drawings, with a minimum of one tested dowel per group. If no test value is

indicated on the Drawings but the installed dowel is under direct tension, the Contractor shall notify the Engineer to verify the required test value.

2. Contractor shall submit a plan and schedule indicating locations of dowels to be tested, load test values and proposed dowel testing procedure (including a diagram of the testing equipment proposed for use) prior to conducting any testing. The testing equipment shall have a minimum of three support points and shall be of sufficient size to locate the edge of supports no closer than two times the anchor embedment depth from the center of the anchor.
3. Where Contract Documents indicate adhesive dowel design is the Contractor's responsibility, the Contractor shall submit a plan and schedule indicating locations of dowels to be tested and load test values, sealed by a Professional Engineer currently registered in the State of Georgia. The Contractor shall also submit documentation indicating the Contractor's testing procedures have been reviewed and the proposed procedures are acceptable.
4. Adhesive Dowel shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the dowel after loading shall be considered a failure. Dowels exhibiting damage shall be removed and replaced. If more than 5 percent of tested dowels fail, then 100 percent of dowels shall be proof tested.
5. Proof testing of adhesive dowels shall be performed by an independent testing laboratory hired directly by the Contractor. The Contractor shall be responsible for costs of all testing, including additional testing required due to previously failed tests.

### **3.05 SPLICING**

- A. Reinforcing bar splices shall only be used at locations shown on the Drawings. When it is necessary to splice reinforcing at points other than where shown, the splice shall be as acceptable to the Engineer.
- B. The length of lap for reinforcing bars, unless otherwise shown on the Drawings shall be in accordance with ACI 318 for a class B splice.
- C. Laps of welded wire fabric shall be in accordance with ACI 318. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet. Wires shall be staggered and tied in such a manner that they cannot slip.
- D. Mechanical splices shall be used only where shown on the drawings or when approved by the Engineer.
- E. Couplers which are located at a joint face shall be a type which can be set either flush or recessed from the face as shown on the Drawings. The couplers shall be sealed during concrete placement to completely eliminate concrete or cement paste from entering.

After the concrete is placed, couplers intended for future connections shall be plugged and sealed to prevent any contact with water or other corrosive materials. Threaded couplers shall be plugged with plastic plugs which have an O-ring seal.

### **3.06 INSPECTION**

- A. The Contractor shall advise the Engineer of his intentions to place concrete and shall allow him adequate time to inspect all reinforcing steel before concrete is placed.
- B. The Contractor shall advise the Engineer of his intentions to place grout in masonry walls and shall allow him adequate time to inspect all reinforcing steel before grout is placed.

### **3.07 CUTTING OF EMBEDDED REBAR**

- A. The Contractor shall not cut embedded rebar cast into structural concrete without prior approval.

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**SECTION 03 30 00**  
**CAST-IN-PLACE CONCRETE**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Provide all labor, equipment, materials and services necessary for the manufacture, transportation and placement of all plain and reinforced concrete work, as shown on the Drawings or as ordered by the Engineer.
  
- B. The requirements in this section shall apply to the following types of concrete:
  - 1. Class A1 Concrete: Normal weight structural concrete to be used in all structures qualifying as environmental concrete structures that are designed in accordance with ACI 350 including pump stations, tanks, basins, process structures, and any structures containing fluid or process chemicals or other materials used in treatment process.
  
  - 2. Class A2 Concrete: Normal weight structural concrete in all structures other than structures qualifying as environmental concrete structures as described above, and for all sidewalks and pavement.
  
  - 3. Class A3 Concrete: Not Used
  
  - 4. Class A4 Concrete: Normal weight structural concrete to be used where specifically called for on Contract Drawings or areas where specifically requested by Contractor and approved by Engineer. Class A4 concrete is identical to Class A2 concrete except that coarse aggregate specified in Article 2.05 below shall be Size #8 in accordance with ASTM C33.
  
  - 5. Class A5 Concrete: Not Used
  
  - 6. Class B Concrete: Normal weight structural concrete used for duct bank encasements, catch basins, fence and guard post embedment, concrete fill, and other areas where specifically noted on Contract Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 11 00 – Concrete Formwork
  
- B. Section 03 21 00 – Reinforcing Steel
  
- C. Section 03 15 00 – Concrete Accessories
  
- D. Section 03 15 16 – Joints in Concrete

- E. Section 03 35 00 – Concrete Finishes
- F. Section 03 39 00 – Concrete Curing
- G. Section 03 60 00 – Grout

### **1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Amendments to the International Building Code – 2018 Edition
  - 2. ACI 214 – Guide to Evaluation of Strength Test Results of Concrete
  - 3. ACI 301 – Specifications for Structural Concrete
  - 4. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete
  - 5. ACI 305 – Guide to Hot Weather Concreting
  - 6. ACI 306 – Guide to Cold Weather Concreting
  - 7. ACI 309 – Guide for Consolidation of Concrete
  - 8. ACI 318 – Building Code Requirements for Structural Concrete and Commentary
  - 9. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures
  - 10. ASTM C 31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field
  - 11. ASTM C 33 – Standard Specification for Concrete Aggregates
  - 12. ASTM C 39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
  - 13. ASTM C42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
  - 14. ASTM C 88 – Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate
  - 15. ASTM C 94 – Standard Specification for Ready-Mixed Concrete
  - 16. ASTM C 114 – Standard Test Method for Chemical Analysis of Hydraulic Cement

17. ASTM C 136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
18. ASTM C 138 – Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
19. ASTM C 143 – Standard Test Method for Slump of Hydraulic Cement Concrete
20. ASTM C 150 – Standard Specification for Portland Cement
21. ASTM C 172 – Standard Practice for Sampling Freshly Mixed Concrete
22. ASTM C 192 – Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
23. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
24. ASTM C 260 – Standard Specification for Air-Entraining Admixtures for Concrete
25. ASTM C 295 – Standard Guide for Petrographic Examination of Aggregates for Concrete
26. ASTM C 457 – Standard Test Method for Microscopical Determination of the Air-Void System in Hardened Concrete
27. ASTM C 494 – Standard Specification for Chemical Admixtures for Concrete
28. ASTM C 595 – Standard Specification for Blended Hydraulic Cements
29. ASTM C 618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
30. ASTM C 989 – Standard Specification for Slag Cement for Use in Concrete and Mortars
31. ASTM C 1077 – Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
32. ASTM C 1260 – Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)
33. ASTM C 1567 – Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
34. ASTM C 1602 – Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

35. ASTM C 1778 – Reducing the Risk of Deleterious Alkali – Aggregate Reaction in Concrete

#### **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  1. Sources of all materials and certifications of compliance with specifications for all materials.
  2. Certified current (less than 1 year old) chemical analysis of the Portland Cement or Blended Cement to be used.
  3. Certified current (less than 1 year old) chemical analysis of fly ash or slag cement to be used.
  4. Aggregate test results showing compliance with required standards, i.e., sieve analysis, potential reactivity, aggregate soundness tests, petrographic analysis, mortar bar expansion testing, etc.
  5. Manufacturer's data on all admixtures stating compliance with required standards.
  6. Concrete mix design for each class of concrete specified herein.
  7. Field experience records and/or trial mix data for the proposed concrete mixes for each class of concrete specified herein.

#### **1.05 QUALITY ASSURANCE**

- A. Tests on materials used in the production of concrete shall be required as specified in Part 2 – Products. These tests shall be performed by an independent testing laboratory approved by the Engineer at no additional cost to the Owner.
- B. Trial concrete mixes shall be tested when required in accordance with Article 3.01 at no additional cost to the Owner.
- C. Field quality control tests, as specified in Article 3.10, unless otherwise stated, will be performed by a materials testing consultant employed by the Owner. However, the Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. Any individual who samples and tests concrete to determine if the concrete is being produced in accordance with this Specification shall be certified as a Concrete Field Testing Technician, Grade I, in accordance with ACI CP-2. Testing laboratory shall conform to requirements of ASTM C-1077.

#### **1.06 CONCRETE COORDINATION CONFERENCE**

- A. Unless waived by the Engineer, prior to any concrete submittals and at least 35 days prior to the start of the concrete construction schedule, the Contractor shall conduct a meeting at the site. The purpose of the meeting is to review the proposed concrete mix designs, to discuss the proposed approaches and procedures for mixing, transporting, placing, testing, finishing, and curing of all aspects of concrete work to ensure the concrete construction is performed in accordance with the Specifications, and to clarify roles of the parties involved. The Contractor shall send a concrete coordination conference agenda to all attendees 20 days prior to a mutually agreed upon date for the conference.
- B. As a minimum the agenda shall include:
1. Concrete Materials and Mix Designs
  2. Inspection Responsibilities
  3. Concrete Sampling and Testing Specification Requirements
  4. Cylinder Storage and Transportation
  5. Acceptance/Rejection Responsibility and Authority for Fresh Concrete
  6. Concrete finishing
  7. Concrete Curing
  8. Test Report Distribution
  9. Miscellaneous Items
- C. The Contractor shall require responsible representatives of every party who is concerned with the concrete work to attend the conference, including but not limited to the following:
1. Contractor's superintendent
  2. Engineer
  3. Owner's representative (if he chooses to attend)
  4. Laboratory retained for trial batching and construction quality control testing for the concrete.
  5. Any subcontractors involved in placing, finishing, and curing of concrete
  6. Concrete supplier
  7. Concrete pumping subcontractor (if pumping is being proposed)

- D. Minutes of the meeting shall be recorded, typed, and printed by the Contractor and distributed to all attendees and any other concerned parties within five days of the meeting.

## **PART 2 – PRODUCTS**

### **2.01 HYDRAULIC CEMENT**

#### **A. Portland Cement**

1. Portland Cement shall be Type II conforming to ASTM C 150. Type I cement may be used provided either fly ash or slag cement is also included in the mix in accordance with Articles 2.02 or 2.03 respectively.
2. When potentially reactive aggregates as defined in Article 2.05 are to be used in concrete mix, cement shall meet the following requirements:
  - a. For concrete mixed with only Portland Cement, the total alkalis in the cement (calculated as the percentage of  $Na_2O$  plus 0.658 times the percentage of  $K_2O$ ) shall not exceed 0.40%.
  - b. For concrete mixed with Portland Cement and an appropriate amount of fly ash (Article 2.02) or slag cement (Article 2.03) the total alkalis in the Portland Cement (calculated as the percentage of  $Na_2O$  plus 0.658 times the percentage of  $K_2O$ ) shall not exceed 0.85%.
3. When non-reactive aggregates as defined in Article 2.05 are used in concrete mix, total alkalis in the cement shall not exceed 1.0%.
4. The proposed Portland Cement shall not contain more than 8% tricalcium aluminate and more than 12% tetracalcium aluminoferrite.

#### **B. Blended Cement**

1. Blended cements shall be Type IP (Portland Fly Ash Cement) or Type IS (Portland Slag Cement) conforming to ASTM C 595.
2. Type IP cement shall be an interground blend of Portland Cement and fly ash in which the fly ash constituent is between 15% and 25% of the weight of the total blend.
3. Type IS cement shall be an interground blend of Portland Cement and slag cement in which the slag constituent is between 35% and 50% of the weight of the total blend.
4. Fly ash and slag cement used in the production of blended cements shall meet the requirements of Articles 2.02 and 2.03, respectively.

5. When reactive aggregates as defined in Article 2.05 are used in concrete mix, the total alkalies in the Portland Cement (calculated as the percentage of Na<sub>2</sub>O plus 0.658 times the percentage of K<sub>2</sub>O) shall not exceed 0.85%. The percentage of fly ash or slag cement shall be set to meet provisions of Article 2.05.G.2.
- C. Different types of cement shall not be mixed nor shall they be used alternately except when authorized in writing by the Engineer. Different brands of cement or the same brand from different mills may be used alternately. A resubmittal will be required if different cements are proposed during the Project.
- D. Cement shall be stored in a suitable weather-tight building so as to prevent deterioration or contamination. Cement which has become caked, partially hydrated, or otherwise damaged will be rejected.

## **2.02 FLY ASH**

- A. Fly ash shall meet the requirements of ASTM C 618 for Class F, except that the loss on ignition shall not exceed 4%. Fly ash shall also meet the optional physical requirements for uniformity as shown in Table 3 of ASTM C 618.
- B. For fly ash to be used in the production of type IP cement, the Pozzolan Activity Index shall be greater than 75% as specified in Table 3 of ASTM C 595.
- C. Where reactive aggregates as defined in Article 2.05 are used in concrete mix, the fly ash constituent shall be between 15% and 25% of the total weight of the combined Portland Cement and fly ash. The percentage of fly ash shall be set to meet the mean mortar bar expansion requirements in provisions of Article 2.05.G.2.
- D. For Type A1 concrete as required for use in environmental concrete structures, i.e. process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.
- E. Additional fly ash shall not be included in concrete mixed with Type IS or IP cement.

## **2.03 SLAG CEMENT**

- A. Slag cement shall meet the requirements of ASTM C 989 including tests for effectiveness of slag in preventing excessive expansion due to alkali-aggregate reactivity as described in Appendix X-3 of ASTM C 989.
- B. Where reactive aggregates as defined in Article 2.05 are used in concrete mix, the slag cement constituent shall be between 35% and 40% of the total weight of the combined Portland Cement and slag. The percentage of slag cement shall be set to meet the mean mortar bar expansion requirements in provisions of Article 2.05.G.2.

- C. For Type A1 concrete as required for use in environmental concrete structures, i.e. process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.
- D. Additional slag cement shall not be included in concrete mixed with type IS or IP cement.

#### **2.04 WATER**

- A. Water used for mixing concrete shall be clear, potable and free from deleterious substances such as objectionable quantities of silty organic matter, alkali, salts and other impurities.
- B. Water shall not contain more than 100 PPM chloride.
- C. Water shall not contain more than 500 PPM dissolved solids.
- D. Water shall have a pH in the range of 4.5 to 8.5.
- E. Water shall meet requirements of ASTM C 1602.

#### **2.05 AGGREGATES**

- A. All aggregates used in normal weight concrete shall conform to ASTM C 33.
- B. Fine Aggregate (Sand) in the various concrete mixes shall consist of natural or manufactured siliceous sand, clean and free from deleterious substances, and graded within the limits of ASTM C 33.
- C. Coarse aggregates shall consist of hard, clean, durable gravel, crushed gravel or crushed rock. Coarse aggregate shall be size #57 or #67 as graded within the limits given in ASTM C 33 unless otherwise specified.
- D. For Class A4 concrete, coarse aggregate shall be Size #8 in accordance with ASTM C33.
- E. Aggregates shall be tested for gradation by sieve analysis tests in conformance with ASTM C 136.
- F. Aggregates shall be tested for soundness in accordance with ASTM C 88. The loss resulting after five cycles shall not exceed 10 percent for fine or coarse aggregate when using either magnesium sulfate or sodium sulfate.
- G. All aggregates shall be evaluated in accordance with ASTM C 1778 to determine potential reactivity. All aggregates shall be considered reactive unless they meet the requirements below for non-reactive aggregates. Aggregates with a lithology essentially similar to sources in the same region found to be reactive in service shall be considered reactive regardless of the results of the tests above.



1. Non-reactive aggregates shall meet the following requirements:
    - a. A petrographic analysis in accordance with ASTM C295 shall be performed to identify the constituents of the fine and coarse aggregate. Non-reactive aggregates shall meet the following limitations:
      - 1) Optically strained, microfractured, or microcrystalline quartz, 5.0%, maximum.
      - 2) Chert or chalcedony, 3.0%, maximum.
      - 3) Tridymite or cristobalite, 1.0%, maximum.
      - 4) Opal, 0.5%, maximum.
      - 5) Natural volcanic glass in volcanic rocks, 3.0%, maximum.
  2. Concrete mixed with reactive aggregates shall meet the following requirements:
    - a. If aggregates are deemed potentially reactive as per ASTM C-1778 and fly ash or slag cement is included in proposed concrete mix design, proposed concrete mix including proposed aggregates shall be evaluated by ASTM C-1567. Mean mortar bar expansions at 16 days shall be less than 0.08%. Tests shall be made using exact proportion of all materials proposed for use on the job in design mix submitted.
    - b. If aggregates are deemed potentially reactive as per ASTM C-1778 and a straight cement mix without fly ash or slag cement is proposed for concrete mix design, aggregates shall be evaluated by ASTM C-1260. Mean mortar bar expansions at 16 days shall be less than 0.08%.
- H. Contractor shall submit a new trial mix to the Engineer for approval whenever a different aggregate or gradation is proposed.

## **2.06 STRUCTURAL MACRO FIBERS : NOT USED**

## **2.07 ADMIXTURES**

- A. Air entraining agent shall be added to all concrete unless noted otherwise. The agent shall consist of a neutralized vinsol resin solution or a purified hydrocarbon with a cement catalyst which will provide entrained air in the concrete in accordance with ASTM C 260. The admixture proposed shall be selected in advance so that adequate samples may be obtained and the required tests made. Air content of concrete, when placed, shall be within the ranges given in the concrete mix design.
- B. The following admixtures are required or used for water reduction, slump increase, and/or adjustment of initial set. Admixtures permitted shall confirm to the requirements of

ASTM C 494. Admixtures shall be non-toxic after 30 days and shall be compatible with and made by the same manufacturer as the air-entraining admixtures.

1. Water reducing admixture shall conform to ASTM C 494, Type A and shall contain no more than 0.05% chloride ions. Acceptable products are "Eucon Series" by the Euclid Chemical Company, "Master Pozzoloth Series" by BASF, and "Plastocrete Series" by Sika Corporation.
  2. High range water reducer shall be sulfonated polymer conforming to ASTM C 494, Type F or G. The high range water reducer shall be added to the concrete at either the batch plant or at the job site and may be used in conjunction with a water reducing admixture. The high range water reducer shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician. A standby system shall be provided and tested prior to each day's operation of the job site system. Concrete shall be mixed at mixing speed for a minimum of 100 mixer revolutions after the addition of the high range water reducer. Acceptable products are "Eucon 37" or Plastol 5000 by the Euclid Chemical Company, "Master Rheobuild 1000 or Master Glenium Series" by BASF, and "Daracem 100 or Advaflo Series" by W.R. Grace.
  3. A non-chloride, non-corrosive accelerating admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C 494, Type C or E, and shall not contain more chloride ions than are present in municipal drinking water. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year's duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures. Acceptable products are "Accelguard 80/90 or NCA" by the Euclid Chemical Company and "Daraset" by W.R. Grace.
  4. A water reducing retarding admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C494, Type D and shall not contain more than 0.05% chloride ions. Acceptable products are "Eucon NR or Eucon Retarder 100" by the Euclid Chemical Company, "Pozzoloth Retarder" by BASF, and "Plastiment" by Sika Corporation.
- C. Admixtures containing calcium chloride, thiocyanate or more than 0.05 percent chloride ions are not permitted. The addition of admixtures to prevent freezing is not permitted.
- D. The Contractor shall submit manufacturer's data including the chloride ion content of each admixture and certification from the admixture manufacturer that all admixtures utilized in the design mix are compatible with one another and properly proportioned prior to mix design review.

## **2.08 CONCRETE MIX DESIGN**

- A. The proportions of cement, aggregates, admixtures and water used in the concrete mixes shall be based on the results of field experience or preferably laboratory trial

mixes in conformance with Section 5.3. "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318 and ACI 350. When trial mixes are used they shall also conform to Article 3.01 of this Section of the Specifications. If field experience records are used, concrete strength results shall be from concrete mixed with all of the ingredients proposed for use on job used in similar proportions to mix proposed for use on job. Contractor shall submit verification confirming this stipulation has been followed. Field experience records and/or trial mix data used as the basis for the proposed concrete mix design shall be submitted to the Engineer along with the proposed mix.

B. Structural concrete shall conform to the following requirements. Cementitious materials refer to the total combined weight of all cement, fly ash, and slag cement contained in the mix.

1. Compressive Strength (28-Day)

Concrete Class A1, A5	4,500 psi (minimum)
Concrete Class A2, A3, A4	4,000 psi (minimum)
Concrete Class B	3,000 psi (minimum)

2. Water/cementitious materials ratio, by weight

	Maximum	Minimum
Concrete Class A1, A5	0.42	0.39
Concrete Class A2, A3, A4	0.45	0.39
Concrete Class B	0.50	0.39

3. Slump range

- a. 4" nominal unless high range water reducing admixture is used
- b. 8" max if high range water reducing admixture is used.

4. Air Content

Concrete Class A1, A2, A4, A5	6% ±1.5%
Concrete Class A3, B	3% Max (non air-entrained)

## PART 3 – EXECUTION

### 3.01 TRIAL MIXES

- A. When trial mixes are used to confirm the quality of a proposed concrete mix in accordance with Section 5.3, "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318 and ACI 350, an independent qualified testing laboratory designated and retained by the Contractor shall test a trial batch of each of the preliminary concrete mixes submitted by the Contractor. The trial batches shall be prepared using the aggregates, cement and admixtures proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain enough samples to satisfy requirements stated below. Tests on individual materials stated in PRODUCTS should already be performed before any trial mix is done. The cost of laboratory trial batch tests for each specified concrete mix will be borne by the Contractor and the Contractor shall furnish and deliver the materials to the testing laboratory at no cost to the Owner.
  
- B. The independent testing laboratory shall prepare a minimum of fifteen (15) standard test cylinders in accordance with ASTM C 31 in addition to conducting slump (ASTM C 143), air content (C 231) and unit weight (C 138) tests. Compressive strength test on the cylinders shall subsequently be performed by the same laboratory in accordance with ASTM C 39 as follows: Test 3 cylinders at age 7 days; test 3 cylinders at age 21 days; test 3 cylinders at age 28 days and test 3 cylinders at 56 days. The cylinders shall be carefully identified as "Trial Mix, Contract No. , Product ." If the average 28-day compressive strength of the trial mix is less than that specified, or if any single cylinder falls below the required strength by more than 500 psi, the mix shall be corrected, another trial batch prepared, test cylinders taken, and new tests performed as before. Any such additional trial batch testing required shall be performed at no additional cost to the Owner. Adjustments to the mix shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor.

### **3.02 PRODUCTION OF CONCRETE**

- A. All concrete shall be machine mixed. Hand mixing of concrete will not be permitted. The Contractor may supply concrete from a ready mix plant or from a site mixed plant. In selecting the source for concrete production the Contractor shall carefully consider its capability for providing quality concrete at a rate commensurate with the requirements of the placements so that well bonded, homogenous concrete, free of cold joints, is assured.
  
- B. Ready-Mixed Concrete
  - 1. At the Contractor's option, ready-mixed concrete may be used meeting the requirements for materials, batching, mixing, transporting, and placing as specified herein and in accordance with ASTM C 94.
  
  - 2. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter shall be of the resettable, recording type, and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.

3. Each batch of concrete shall be mixed in a truck mixer for not less than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.
4. Truck mixers and their operation shall be such that the concrete throughout the mixed batch, as discharged, is within acceptable limits of uniformity with respect to consistency, mix and grading. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than one inch when the specified slump is 3 inches or less, or if they differ by more than 2 inches when the specified slump is more than 3 inches, the mixer shall not be used on the work unless the causing condition is corrected and satisfactory performance is verified by additional slump tests. All mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.
5. Ready-mixed concrete shall be delivered to the site for the work and discharge shall be completed before the drum has been revolved 300 revolutions and within the time requirements stated in Article 3.03 of this Section.
6. Each and every concrete delivery shall be accompanied by a delivery ticket containing at least the following information:
  - a. Date and truck number
  - b. Ticket number
  - c. Mix designation of concrete
  - d. Cubic yards of concrete
  - e. Cement brand, type and weight in pounds
  - f. Weight in pounds of fine aggregate (sand)
  - g. Weight in pounds of coarse aggregate (stone)
  - h. Air entraining agent, brand, and weight in pounds and ounces
  - i. Other admixtures, brand, and weight in pounds and ounces
  - j. Water, in gallons, stored in attached tank

- k. Water, in gallons, maximum that can be added without exceeding design water/cementitious materials ratio
  - l. Water, in gallons, actually used (by truck driver)
  - m. Time of loading
  - n. Time of delivery to job (by truck driver)
7. Any truck delivering concrete to the job site, which is not accompanied by a delivery ticket showing the above information will be rejected and such truck shall immediately depart from the job site.
8. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the Engineer.

C. Site Mixed Concrete

1. Scales for weighing concrete ingredients shall be accurate when in use within  $\pm 0.4$  percent of their total capacities. Standard test weights shall be available to permit checking scale accuracy.
2. Operation of batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances:
- a. Cement, fly ash, or slag cement  $\pm 1$  percent
  - b. Water  $\pm 1$  percent
  - c. Aggregates  $\pm 2$  percent
  - d. Admixtures  $\pm 3$  percent
3. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.
4. The concrete shall be mixed in a batch mixer capable of thoroughly combining the aggregates, cement, and water into a uniform mass within the specified mixing time, and of discharging the concrete without harmful segregation. The mixer shall bear a manufacturer's rating plate indicating the rate capacity and the

recommended revolutions per minute and shall be operated in accordance therewith.

5. Mixers with a rate capacity of 1 cu.yd. or larger shall conform to the requirements of the Plant Mixer Manufacturers' Division of the Concrete Plant Manufacturers' Bureau.
6. Except as provided below, batches of 1 cu. yd. or less shall be mixed for not less than 1 minute. The mixing time shall be increased 15 seconds for each cubic yard or fraction thereof of additional capacity.
7. Shorter mixing time may be permitted provided performance tests made in accordance with of ASTM C 94 indicate that the time is sufficient to produce uniform concrete.
8. Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three-quarters of the required mixing time shall take place after the last of the mixing water has been added.
9. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixer blades shall be replaced when they have lost 10 percent of their original height.
10. Air-entraining admixtures and other chemical admixtures shall be charged into the mixer as solutions and shall be measured by means of an approved mechanical dispensing device. The liquid shall be considered a part of the mixing water. Admixtures that cannot be added in solution may be weighed or may be measured by volume if so recommended by the manufacturer.
11. If two or more admixtures are used in the concrete, they shall be added separately to avoid possible interaction that might interfere with the efficiency of either admixture or adversely affect the concrete.
12. Addition of retarding admixtures shall be completed within 1 minute after addition of water to the cement has been completed, or prior to the beginning of the last three-quarters of the required mixing, whichever occurs first. Retarding admixtures shall not be used unless approved by the Engineer.
13. Concrete shall be mixed only in quantities for immediate use and within the time and mixing requirements of ASTM C 94.

### **3.03 CONCRETE PLACEMENT**

- A. No concrete shall be placed prior to approval of the concrete mix design. Concrete placement shall conform to the recommendations of ACI 304.

- B. Prior to concrete placement, all reinforcement shall be securely and properly fastened in its correct position. Formwork shall be clean, oiled and form ties at construction joints shall be retightened. All bucks, sleeves, castings, hangers, pipe, conduits, bolts, anchors, wire, and any other fixtures required to be embedded therein shall be in place. Forms for openings to be left in the concrete shall be in place and anchored by the Contractor. All loose debris in bottoms of forms or in keyways shall be removed and all debris, water, snow, ice and foreign matter shall be removed from the space to be occupied by the concrete. The Contractor shall notify the Engineer in advance of placement, allowing sufficient time for a concurrent inspection and for any corrective measures which are subsequently required.
- C. On horizontal joints where concrete is to be placed on hardened concrete, flowing concrete containing a high range water reducing admixture or cement grout shall be placed with a slump not less than 8 inches for the initial placement at the base of the wall. Concrete or cement grout shall meet all strength and service requirements specified herein for applicable class of concrete. This concrete shall be worked well into the irregularities of the hard surface.
- D. All concrete shall be placed during the daylight hours except with the consent of the Engineer. If special permission is obtained to carry on work during the night, adequate lighting must be provided.
- E. When concrete arrives at the project with slump below that suitable for placing, as indicated by the Specifications, water may be added to bring the concrete within the specified slump range provided that the design water-cementitious materials ratio is not exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing required. Water may be added only to full trucks. On-site tempering shall not relieve the Contractor from furnishing a concrete mix that meets all specified requirements.
- F. Concrete shall be conveyed as rapidly as practicable to the point of deposit by methods which prevent the separation or loss of the ingredients. It shall be so deposited that rehandling will be unnecessary. Discharge of the concrete to its point of deposit shall be completed within 90 minutes after the addition of the cement to the aggregates. In hot weather, or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed the requirements stated in Article 3.09 of this Section.
- G. Where concrete is conveyed to position by chutes, a practically continuous flow in the chute shall be maintained. The angle and discharge arrangement of the chute shall be such as to prevent segregation of the concrete ingredients. The delivery end of the chute shall be as close as possible to the point of deposit and in no case shall the free pour from the delivery end of the chute exceed five feet, unless approved otherwise.
- H. Special care must be exercised to prevent splashing of forms or reinforcement with concrete, and any such splashes or accumulations of hardened or partially hardened



concrete on the forms or reinforcement above the general level of the concrete already in place must be removed before the work proceeds. Concrete shall be placed in all forms in such way as to prevent any segregation.

- I. Placing of concrete shall be so regulated that the pressure caused by the wet concrete shall not exceed that used in the design of the forms.
- J. All concrete for walls shall be placed through openings in the form spaced at frequent intervals or through tremies (heavy duct canvas, rubber, etc.), equipped with suitable hopper heads. Tremies shall be of variable lengths so the free fall shall not exceed five (5) feet and a sufficient number shall be placed in the form to ensure the concrete is kept level at all times.
- K. When placing concrete which is to be exposed, sufficient illumination shall be provided in the interior of the forms so the concrete, at places of deposit, is visible from deck and runways.
- L. Concrete shall be placed so as to thoroughly embed all reinforcement, inserts, and fixtures.
- M. When forms are removed, surfaces shall be even and dense, free from aggregate pockets or honeycomb. To achieve this, concrete shall be consolidated using mechanical vibration, supplemented by forking and spading by hand in the corners and angle of forms and along form surfaces while the concrete is plastic under the vibratory action. Consolidation shall conform to ACI 309.
- N. Mechanical vibration shall be applied directly to the concrete, unless otherwise approved by the Engineer. The bottom of vibrators used on floor slabs must not be permitted to ride the form supporting the slab. Vibration shall be applied at the point of deposit and in the area of freshly placed concrete by a vertical penetration of the vibrator. Vibrators shall not be used to move concrete laterally within the forms.
- O. The intensity of vibration shall be sufficient to cause settlement of the concrete into place and to produce monolithic joining with the preceding layer. It shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures with a vibrator transmitting not less than 7,500 impulses per minute. Since the duration of vibration per square foot of surface is dependent on the frequency (impulses per minute), size of vibrator, and slump of concrete, the length of time must therefore be determined in the field. Vibration, however, shall not be continued in any one location to the extent that pools of grout are formed.
- P. Care shall be taken to prevent cold joints when placing concrete in any portion of the work. The concrete placing rate shall be such as to ensure that each layer is placed while the previous layer is soft or plastic, so that the two layers can be made monolithic by penetration of the vibrators. Maximum thickness of concrete layers shall be 18 inches. The surface of the concrete shall be level whenever a run of concrete is stopped.

- Q. To prevent featheredges, construction joints located at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface, so the angle between such inclined surface and the exposed concrete surface will be not less than 50°.
- R. In placing unformed concrete on slopes, the concrete shall be placed ahead of a non-vibrated slip-form screed extending approximately 2-1/2 feet back from its leading edge. The method of placement shall provide a uniform finished surface with the deviation from the straight line less than 1/8 inch in any concrete placement. Concrete ahead of the slip-form screed shall be consolidated by internal vibrators so as to ensure complete filling under the slip-form. Prior to placement of concrete on sloped walls or slabs, the Contractor shall submit a plan specifically detailing methods and sequence of placements, proposed concrete screed equipment, location of construction joints and waterstops, and/or any proposed deviations from the aforementioned to the Engineer for review and approval.
- S. Concrete shall not be placed during rains sufficiently heavy or prolonged to wash mortar from coarse aggregate on the forward slopes of the placement. Once placement of concrete has commenced in a block, placement shall not be interrupted by diverting the placing equipment to other uses.

#### **3.04 PLACING FLOOR SLABS ON GRADE**

- A. The subgrade for slabs on ground shall be well drained and of adequate and uniform loadbearing nature. The in-place density of the subgrade soils shall be at least the minimum required by the specifications. No foundation, slab, or pavement concrete shall be placed until the depth and character of the foundation soils have been inspected and approved by the materials testing consultant.
- B. The subgrade shall be free of frost before concrete placing begins. If the temperature inside a building where concrete is to be placed is below freezing it shall be raised and maintained above 50° long enough to remove all frost from the subgrade.
- C. The subgrade shall be moist at the time of concreting. If necessary, it shall be dampened with water in advance of concreting, but there shall be no free water standing on the subgrade nor any muddy or soft spots when the concrete is placed.
- D. Thirty-pound felt paper shall be provided between edges of slab on grade and vertical and horizontal concrete surfaces, unless otherwise indicated on the Drawings.
- E. Contraction joints shall be provided in slabs-on-grade at locations indicated on the Drawings. Contraction joints shall be installed as per Section 03 15 16 – Joints in Concrete.

- F. Floor slabs shall be screeded level or pitched to drain as indicated on the Drawings. Finishes shall conform with requirements of Section 03 35 00 – Concrete Finishes. Interior floor slabs shall be placed with non-air-entrained concrete (Class A3) if a steel troweled or hardened finish is required.

### **3.05 PLACING CONCRETE UNDERWATER (CLASS A5 CONCRETE)**

- A. Placing concrete underwater (tremie concrete) will be permitted only when shown on the Drawings. Concrete deposited under water shall be carefully placed in a compacted mass in final position by means of a tremie, a closed bottom dump bucket or other approved method. Care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. Underwater formwork shall be watertight. The consistency of the concrete shall be regulated to prevent segregation of materials. The method of depositing concrete shall be regulated such that the concrete enters the mass of the previously placed concrete from within, displacing water with a minimum disturbance to the surface of the concrete.
- B. Tremie shall consist of a tube having a diameter of not less than 10 inches and constructed in sections having flanged couplings fitted with gaskets. The tremie shall be supported to permit free movement of the discharge and over the entire top surface of the work and shall permit rapid lowering when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow shall then be stopped by lowering the tremie. The flow shall be continuous until the placement has been completed.

### **3.06 PLACING CONCRETE UNDER PRESSURE**

- A. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall have the capacity for the operation. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. To obtain the least line resistance, the layout of the pipeline system shall contain a minimum number of bends with no change in pipe size. If two sizes of pipe must be used, the smaller diameter should be used at the pump end and the larger at the discharge end. When pumping is completed, the concrete remaining in the pipelines, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.
- B. Priming of the concrete pumping equipment shall be with cement grout only. Use of specialty mix pump primers or pumping aids will not be allowed.
- C. No aluminum parts shall be in contact with the concrete during the entire placing of concrete under pressure at any time.
- D. Prior to placing concrete under pressure, the Contractor shall submit the concrete mix design together with test results from a materials testing consultant proving the proposed

mix meets all requirements. In addition, an actual pumping test under field conditions is required prior to acceptance of the mix. This test requires a duplication of anticipated site conditions from beginning to end. The batching and truck mixing shall be the same as will be used; the same pump and operator shall be present and the pipe and pipe layouts will reflect the maximum height and distance contemplated. All submissions shall be subject to approval by the Engineer.

- E. If the pumped concrete does not produce satisfactory end results, the Contractor shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.
- F. The pumping equipment must have two cylinders and be designed to operate with one cylinder only in case the other one is not functioning. In lieu of this requirement, the Contractor may have a standby pump on the site during pumping.
- G. The minimum diameter of the hose (conduits) shall be four inches.
- H. Pumping equipment and hoses (conduits) that are not functioning properly shall be replaced.
- I. Concrete samples for quality control in accordance with Article 3.10 will be taken at the placement (discharge) end of the line.

### **3.07 ORDER OF PLACING CONCRETE**

- A. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints shown on the Drawings and maximum lengths as indicated on Drawings. Where required on the Drawings and wherever else practical, the placing of such units shall be done in a strip pattern in accordance with ACI 302.1. A minimum of 72 hours shall pass prior to placing concrete directly adjacent to previously placed concrete.

### **3.08 CONCRETE WORK IN COLD WEATHER**

- A. Cold weather concreting procedures shall conform to the requirements of ACI 306.
- B. The Engineer may prohibit the placing of concrete at any time when air temperature is 40°F. or lower. If concrete work is permitted, the concrete shall have a minimum temperature, as placed, of 55°F. for placements less than 12" thick, 50°F. for placements 12" to 36" thick, and 45°F. for placements greater than 36" thick. The temperature of the concrete as placed shall not exceed the aforementioned minimum values by more than 20°F, unless otherwise approved by the Engineer.
- C. All aggregate and water shall be preheated. Precautions shall be taken to avoid the possibility of flash set when aggregate or water are heated to a temperature in excess of 100°F. in order to meet concrete temperature requirements. The addition of admixtures to the concrete to prevent freezing is not permitted. All reinforcement, forms, and

concrete accessories with which the concrete is to come in contact shall be defrosted by an approved method. No concrete shall be placed on frozen ground.

### **3.09 CONCRETE WORK IN HOT WEATHER**

- A. Hot weather concreting procedures shall conform to the requirements of ACI 305.
- B. When air temperatures exceed 85°F., or when extremely dry conditions exist even at lower temperatures, particularly if accompanied by high winds, the Contractor and his concrete supplier shall exercise special and precautionary measures in preparing, delivering, placing, finishing, curing and protecting the concrete mix. The Contractor shall consult with the Engineer regarding such measures prior to each day's placing operation and the Engineer reserves the right to modify the proposed measures consistent with the requirements of this Section of the Specifications. All necessary materials and equipment shall be on hand and in position prior to each placing operation.
- C. Preparatory work at the job site shall include thorough wetting of all forms, reinforcing steel and, in the case of slab pours on ground or subgrade, spraying the ground surface on the preceding evening and again just prior to placing. No standing puddles of water shall be permitted in those areas which are to receive the concrete.
- D. The temperature of the concrete mix when placed shall not exceed 90°F.
- E. Temperature of mixing water and aggregates shall be carefully controlled and monitored at the supplier's plant, with haul distance to the job site being taken into account. Stockpiled aggregates shall, if necessary, be shaded from the sun and sprinkled intermittently with water. If ice is used in the mixing water for cooling purposes, it must be entirely melted prior to addition of the water to the dry mix.
- F. Delivery schedules shall be carefully planned in advance so that concrete is placed as soon as practical after it is properly mixed. For hot weather concrete work (air temperature greater than 85°F), discharge of the concrete to its point of deposit shall be completed within 60 minutes from the time the concrete is batched.
- G. The Contractor shall arrange for an ample work force to be on hand to accomplish transporting, vibrating, finishing, and covering of the fresh concrete as rapidly as possible.

### **3.10 QUALITY CONTROL**

- A. Field Testing of Concrete
  - 1. The Contractor shall coordinate with the Engineer's project representative the on-site scheduling of the materials testing consultant personnel as required for concrete testing.

2. Concrete for testing shall be supplied by the Contractor at no additional cost to the Owner, and the Contractor shall provide assistance to the materials testing consultant in obtaining samples. The Contractor shall dispose of and clean up all excess material.

#### B. Consistency

1. The consistency of the concrete will be checked by the materials testing consultant by standard slump cone tests. The Contractor shall make any necessary adjustments in the mix as the Engineer and/or the materials testing consultant may direct and shall upon written order suspend all placing operations in the event the consistency does not meet the intent of the specifications. No payment shall be made for any delays, material or labor costs due to such eventualities.
2. Slump tests shall be made in accordance with ASTM C 143. Slump tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.
3. Concrete with a specified nominal slump shall be placed having a slump within 1" (higher or lower) of the specified slump. Concrete with a specified maximum slump shall be placed having a slump less than the specified slump.

#### C. Unit Weight

1. Samples of freshly mixed concrete shall be tested for unit weight by the materials testing consultant in accordance with ASTM C 138.
2. Unit weight tests will be performed as deemed necessary by the Engineer and each time compressive strength samples are taken.

#### D. Air Content

1. Samples of freshly mixed concrete will be tested for entrained air content by the materials testing consultant in accordance with ASTM C 231.
2. Air content tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.
3. In the event test results are outside the limits specified, additional testing shall occur. Admixture quantity adjustments shall be made immediately upon discovery of incorrect air entrainment.

#### E. Compressive Strength

1. Samples of freshly mixed concrete will be taken by the materials testing consultant and tested for compressive strength in accordance with ASTM C 172, C 31 and C 39, except as modified herein.

2. In general, one sampling shall be taken for each placement in excess of five (5) cubic yards, with a minimum of one (1) sampling for each day of concrete placement operations, or for each one hundred (100) cubic yards of concrete, or for each 5,000 square feet of surface area for slabs or walls, whichever is greater.
3. Each sampling shall consist of at least five (5) 6x12 cylinders or (8) 4x8 cylinders. Each cylinder shall be identified by a tag, which shall be hooked or wired to the side of the container. The materials testing consultant will fill out the required information on the tag, and the Contractor shall satisfy himself that such information shown is correct.
4. The Contractor shall be required to furnish labor to the Owner for assisting in preparing test cylinders for testing. The Contractor shall provide approved curing boxes for storage of cylinders on site. The insulated curing box shall be of sufficient size and strength to contain all the specimens made in any four consecutive working days and to protect the specimens from falling over, being jarred or otherwise disturbed during the period of initial curing. The box shall be erected, furnished and maintained by the Contractor. Such box shall be equipped to provide the moisture and to regulate the temperature necessary to maintain the proper curing conditions required by ASTM C 31. Such box shall be located in an area free from vibration such as pile driving and traffic of all kinds and such that all specimen are shielded from direct sunlight and/or radiant heating sources. No concrete requiring inspection shall be delivered to the site until such storage curing box has been provided. Specimens shall remain undisturbed in the curing box until ready for delivery to the testing laboratory but not less than sixteen hours.
5. The Contractor shall be responsible for maintaining the temperatures of the curing box during the initial curing of test specimens with the temperature preserved between 60°F and 80°F as measured by a maximum-minimum thermometer. The Contractor shall maintain a written record of curing box temperatures for each day curing box contains test specimens. Temperature shall be recorded a minimum of three times a day with one recording at the start of the work day and one recording at the end of the work day.
6. When transported, the cylinders shall not be thrown, dropped, allowed to roll, or be damaged in any way.
7. Compression tests shall be performed in accordance with ASTM C 39. For 6x12 cylinders, two test cylinders will be tested at seven days and two at 28 days. For 4x8 cylinders, three test cylinders will be tested at seven days, three at 28 days. The remaining cylinders will be held to verify test results, if needed.

#### F. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 214, ACI 318, and ACI 350.

2. The strength level of concrete will be considered satisfactory if all of the following conditions are satisfied.
    - a. Every arithmetic average of any three consecutive strength tests equals or exceeds the minimum specified 28-day compressive strength for the mix (see Article 2.08).
    - b. No individual compressive strength test results falls below the minimum specified strength by more than 500 psi.
  3. In the event any of the conditions listed above are not met, the mix proportions shall be corrected for the next concrete placing operation.
  4. In the event that condition 2B is not met, additional tests in accordance with Article 3.10, paragraph H shall be performed.
  5. When a ratio between 7-day and 28-day strengths has been established by these tests, the 7-day strengths shall subsequently be taken as a preliminary indication of the 28-day strengths. Should the 7-day test strength from any sampling be more than 10% below the established minimum strength, the Contractor shall:
    - a. Immediately provide additional periods of curing in the affected area from which the deficient test cylinders were taken.
    - b. Maintain or add temporary structural support as required.
    - c. Correct the mix for the next concrete placement operation, if required to remedy the situation.
  6. All concrete which fails to meet the ACI requirements and these specifications is subject to removal and replacement at no additional cost to the Owner.
- G. When non-compliant concrete is identified, test reports shall be sent immediately to the Engineer for review.
- H. Additional Tests
1. When ordered by the Engineer, additional tests on in-place concrete shall be provided and paid for by the Contractor.
  2. In the event the 28-day test cylinders fail to meet the minimum strength requirements as outlined in Article 3.10, paragraph F, the Contractor shall have concrete core specimens obtained and tested from the affected area immediately.
    - a. Three cores shall be taken for each sample in which the strength requirements were not met.



- b. The drilled cores shall be obtained and tested in conformance with ASTM C 42. The tests shall be conducted by a materials testing consultant approved by the Engineer.
  - c. The location from which each core is taken shall be approved by the Engineer. Each core specimen shall be located, when possible, so its axis is perpendicular to the concrete surface and not near formed joints or obvious edges of a unit of deposit.
  - d. The core specimens shall be taken, if possible, so no reinforcing steel is within the confines of the core.
  - e. The diameter of core specimens should be at least 3 times the maximum nominal size of the course aggregate used in the concrete, but must be at least 2-inches in diameter.
  - f. The length of specimen, when capped, shall be at least twice the diameter of the specimen.
  - g. The core specimens shall be taken to the laboratory and when transported, shall not be thrown, dropped, allowed to roll, or damaged in any way.
  - h. Two (2) copies of test results shall be mailed directly to the Engineer. The concrete in question will be considered acceptable if the average compressive strength of a minimum of three test core specimens taken from a given area equal or exceed 85% of the specified 28-day strength and if the lowest core strength is greater than 75% of the specified 28-day strength.
3. In the event that concrete placed by the Contractor is suspected of not having proper air content, the Contractor shall engage a materials testing consultant approved by the Engineer, to obtain and test samples for air content in accordance with ASTM Specification C 457.

### **3.11 CARE AND REPAIR OF CONCRETE**

- A. The Contractor shall protect all concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance by the Owner. Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface. Care shall be exercised to avoid jarring forms or placing any strain on the ends of projecting reinforcing bars. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at no additional cost to the Owner.
- B. Areas of honeycomb shall be chipped back to sound concrete and repaired as directed.

- C. Concrete formwork blowouts or unacceptable deviations in tolerances for formed surfaces due to improperly constructed or misaligned formwork shall be repaired as directed. Bulging or protruding areas, which result from slipping or deflecting forms shall be ground flush or chipped out and redressed as directed.
- D. Areas of concrete in which cracking, spalling, or other signs of deterioration develop prior to final acceptance shall be removed and replaced or repaired as directed. This stipulation includes concrete that has experienced cracking due to drying or thermal shrinkage of the concrete. Structural cracks shall be repaired using an approved epoxy injection system. Non-structural cracks shall be repaired using an approved hydrophilic resin pressure injected grout system, unless other means of repair are deemed necessary and approved. All repair work shall be performed at no additional cost to the Owner.
- E. Concrete which fails to meet the strength requirements as outlined in Article 3.10, paragraph F, will be analyzed as to its adequacy based upon loading conditions, resultant stresses and exposure conditions for the particular area of concrete in question. If the concrete in question is found unacceptable based upon this analysis, that portion of the structure shall be strengthened or replaced by the Contractor at no additional cost to the Owner. The method of strengthening or extent of replacement shall be as directed by the Engineer.

**END OF SECTION**

**SECTION 03 35 00  
CONCRETE FINISHES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all materials, labor, and equipment required to provide finishes of all concrete surfaces specified herein and shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 30 00 – Cast-in-Place Concrete
- C. Section 03 60 00 – Grout

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. ACI 301 – Specifications for Structural Concrete for Buildings
  - 2. ACI 318 – Building Code Requirements for Structural Concrete

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Manufacturer's literature on all products specified herein.

**PART 2 – PRODUCTS**

**2.01 CONCRETE FLOOR SEALER**

- A. Floor sealer shall be Diamond Clear VOX or Super Diamond Clear VOX by the Euclid Chemical Company, MasterKure CC 300 SB by BASF Master Builder Solutions.

**2.02 CONCRETE LIQUID DENSIFIER AND SEALANT**

- A. Concrete liquid densifier and sealant shall be a high performance, deeply penetrating concrete densifier and sealant. Product shall be odorless, colorless, VOC-compliant,

non-yellowing silicate based solution designed to harden, dustproof and protect concrete floors subjected to heavy vehicular traffic and to resist black rubber tire marks on concrete surfaces. The product must contain a minimum solids content of 20% of which 50% is silicate. Acceptable products are Diamond Hard by the Euclid Chemical Company, Seal Hard by L&M Construction Chemicals and MasterKure HD 210 WB by BASF Master Builder Solutions.

### **2.03 NON-METALLIC FLOOR HARDENER**

- A. The specified non-metallic mineral aggregate hardener shall be formulated, processed, and packaged under stringent quality control at the manufacturer's owned and controlled factory. The hardener shall be a factory-blended mixture of specifically processed graded mineral aggregate, selected Portland cement, and necessary plasticizing agents. Acceptable products shall be "Surflex" by the Euclid Chemical Company, "Harcot" by Sonneborn, "Maximent" by BASF, and "Mastercon" by BASF.

### **2.04 NON-OXIDIZING HEAVY DUTY METALLIC FLOOR HARDENER**

- A. Non-oxidizing, heavy-duty metallic floor hardener shall be formulated, processed, and packaged under stringent quality control at the manufacturer's owned and controlled factory. The hardener shall be a mixture of specifically processed non-rusting aggregate, selected Portland cement, and necessary plasticizing agents. Product shall be "Diamond-Plate" by the Euclid Chemical Company, or Masterplate by BASF Construction Chemicals.

### **2.05 NON-SLIP FLOORING ADDITIVE**

- A. Non-slip flooring additives for slip resistant floors shall be non-metallic. Non-slip flooring additives shall be Frictex NS by BASF Construction Chemicals, A-H Alox by Anti-Hydro, or Euco Grip by the Euclid Chemical Company.

## **PART 3 – EXECUTION**

### **3.01 FINISHES ON FORMED CONCRETE SURFACES**

- A. After removal of forms, the finishes described below shall be applied in accordance with Article 3.06 - Concrete Finish Schedule. Unless the finish schedule specifies otherwise, all surfaces shall receive at least a Type I finish. See Article 3.05 for surfaces to receive paint or protective coatings. The Engineer shall be the sole judge of acceptability of all concrete finish work.
  - 1. Type I - Rough: All fins, burrs, offsets, marks and all other projections left by the forms shall be removed. Projections, depressions, etc. below finished grade required to be removed will only be those greater than 1/4-inch. All holes left by removal of ends of ties, and all other holes, depressions, bugholes, air/blow holes or voids shall be filled solid with cement grout after first being thoroughly wetted

and then struck off flush. The only holes below grade to be filled will be tie holes and any other holes larger than ¼-inch in any dimension. Honeycombs shall be chipped back to solid concrete and repaired as directed by the Engineer. All holes shall be filled with tools, such as sponge floats and trowels, that will permit packing the hole solidly with cement grout. Cement grout shall consist of one part cement to three parts sand, epoxy bonding agent (for tie holes only) and the amount of mixing water shall be as little as consistent with the requirements of handling and placing. Color of cement grout shall match the adjacent wall surface.

2. Type II - Grout Cleaned: Where this finish is required, it shall be applied after completion of Type I finish. After the concrete has been predampened over an extended amount of time to reach the condition of saturated surface dry (SSD), a slurry consisting of one part cement (including an appropriate quantity of white cement in order to produce a color matching the surrounding concrete) and 1-1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Mix proportions shall be submitted to the Engineer after a sample of the work is established and accepted. Any surplus shall be removed by scraping and then rubbing with clean burlap.
3. Type III - Smooth Rubbed: Where this finish is required, it shall be applied after the completion of the Type II finish. No rubbing shall be done before the concrete is thoroughly hardened and the mortar used for patching is firmly set. A smooth, uniform surface shall be obtained by wetting the surface and rubbing it with a carborundum stone to eliminate irregularities. Unless the nature of the irregularities requires it, the general surface of the concrete shall not be cut into. Corners and edges shall be slightly rounded by the use of the carborundum stone. Brush finishing or painting with grout or neat cement will not be permitted. A 100 square foot example shall be established at the beginning of the project to establish acceptability.

### **3.02 SLAB AND FLOOR FINISHES**

- A. The finishes described below shall be applied to floors, slabs, flow channels and top of walls in accordance with Article 3.05 - Concrete Finish Schedule. The Engineer shall be the sole judge of acceptability of all such finish work.
  1. Type "A" - Screeded: This finish shall be obtained by placing screeds at frequent intervals and striking off to the surface elevation required. When a Type "F" finish is subsequently to be applied, the surface of the screeded concrete shall be roughened with a concrete rake to 1/2" minimum deep grooves prior to final set.
  2. Type "B" - Wood or Magnesium Floated: This finish shall be obtained after completion of a Type "A" finish by working a previously screeded surface with a wood or magnesium float or until the desired texture is reached. Floating shall begin when the water sheen has disappeared and when the concrete has

sufficiently hardened so that a person's foot leaves only a slight imprint. If wet spots occur, water shall be removed with a squeegee. Care shall be taken to prevent the formation of laitance and excess water on the finished surface. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finished surface shall be true, even, and free from blemishes and any other irregularities.

3. Type "C" - Cork Floated: This finish shall be similar to Type "B" but slightly smoother than that obtained with a wood float. It shall be obtained by power or band floating with cork floats.
4. Type "D" - Steel Troweled: This finish shall be obtained after completion of a Type "B" finish. When the concrete has hardened sufficiently to prevent excess fine material from working to the surface, the surface shall be compacted and smoothed with not less than two thorough and complete steel troweling operations. In areas which are to receive a floor covering such as tile, resilient flooring, or carpeting, the applicable Specification Sections and Contract Drawings shall be reviewed for the required finishes and degree of flatness. In areas that are intermittently wet such as pump rooms, only one troweling operation is required to provide some trowel marks for slip resistance. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finish shall be brought to a smooth, dense surface, free from defects and blemishes.
5. Type "E" - Broom or Belt: This finish shall provide the surface with a transverse scored texture by drawing a broom or burlap belt across the surface immediately after completion of a Type "B" finish. All edges shall be edged with an 1/8-inch tool as directed by the Engineer.
6. Type "F" - Swept in Grout Topping: This finish shall be applied after a completion of a Type "A" finish. The concrete surface shall be properly cleaned, washed, and coated with a mixture of water and Portland Cement. Cement grout in accordance with Section 03 60 00 – Grout shall then be plowed and swept into neat conformance with the blades or arms of the apparatus by turning or rotating the previously positioned mechanical equipment. Special attention shall be paid to true grades, shapes and tolerances as specified by the manufacturer of the equipment. Before beginning this finish, the Contractor shall notify the Engineer and the equipment manufacturer of the details of the operation and obtain approval and recommendations.
7. Type "G" Hardened Finish: This finish shall be applied after completion of a Type "B" or Type "C" finish and prior to application of a Type "D" finish. Hardeners shall be applied in strict accordance with the manufacturer's requirements. Hardeners shall be applied using a mechanical spreader. The hardener shall be applied in two shakes with the first shake comprising 2/3 of the total amount. Type "D" finish shall be applied following completion of application of the hardener.

- a. Non-metallic floor hardener shall be applied where specifically required on the Contract Drawings at the rate of 1.0 pounds/ft.2.
  - b. Non-oxidizing, heavy-duty metallic floor hardener shall be applied at the loading docks and where specifically required on the Contract Drawings or specified herein at the rate of 1.5 pounds/ft.2.
8. Type "H" - Non-Slip Finish: This finish shall be provided by applying a non-slip flooring additive concurrently with the application of a Type "D" finish and/or installation of floor sealants. Application procedure shall be in accordance with manufacturer's instructions. Finish shall be applied where specifically required on the Contract Drawings or specified herein.
9. Type "J" - Raked Finish: This finish shall be provided by raking the surface as soon as the condition of the concrete permits by making depressions of  $\pm 1/4$  inch.

### **3.03 CONCRETE SEALERS**

- A. Concrete sealers shall be applied where specifically required on the Contract Drawings or specified herein.
- B. Sealers shall be applied after installation of all equipment, piping, etc. and after completion of any other related construction activities. Application of sealers shall be in strict accordance with manufacturer's requirements.
- C. Sealers shall be applied to all floor slabs not painted and not intended to be immersed.
- D. Floor slabs subjected to vehicular traffic shall be sealed with the concrete liquid densifier and sealer.
- E. All other floor slabs to receive sealer shall be sealed with concrete floor sealer.

### **3.04 FINISHES ON EQUIPMENT PADS**

- A. Formed surfaces of equipment pads shall receive a Type III finish.
- B. Top surfaces of equipment pads, except those surfaces subsequently required to receive grout and support equipment bases, shall receive a Type "D" finish, unless otherwise noted. Surfaces which will later receive grout shall, before the concrete takes its final set, be made rough by removing the sand and cement that accumulates on the top to the extent that the aggregate will be exposed with irregular indentations in the surface up to 1/2 inch deep.

### **3.05 FINISHES FOR SURFACES TO RECEIVE PAINT OR COATINGS**

- A. Surfaces indicated or specified to receive paint or special coatings shall be prepared per specifications in Division 09. All products applied to the concrete surfaces during the

placement, finishing, and curing process shall be compatible with the painting or coating system as required by the manufacturer.

### 3.06 CONCRETE FINISH SCHEDULE

Item	Type of Finish
Concrete surfaces indicated to receive textured coating (as noted on Drawings and in Section 09 97 00 – Special Coatings)	I
Inner face of walls of tanks, flow channels, wet wells, perimeter walls, and miscellaneous concrete structures:	
From 1 feet below water surface to bottom of wall	I
From top of wall to 1 feet below water surface	II
Exterior concrete walls below grade	I
Exterior exposed concrete walls, ceilings, beams, manholes, hand holes, miscellaneous structures and columns (including top of wall) to one foot below grade. All other exposed concrete surfaces not specified elsewhere	II
All interior exposed concrete walls and vertical surfaces	III
Interior exposed ceiling, including beams	III
Floors of process equipment tanks or basins, wetwells, flow channels and slabs to receive roofing material or waterproof membranes	B
All interior finish floors of buildings and structures and walking surfaces which will be continuously or intermittently wet	E
All interior finish floors of buildings and structures which are not continuously or intermittently wet	D
Exterior concrete sidewalks, steps, ramps, decks, slabs on grade and landings exposed to weather	E
Floors of process equipment tanks indicated on Drawings to receive grout topping	F
Precast concrete form panels, hollow core planks, double tees	J

**END OF SECTION**



**SECTION 03 39 00**  
**CONCRETE CURING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Protect all freshly deposited concrete from premature drying and from the weather elements. The concrete shall be maintained with minimal moisture loss at a relatively constant temperature for a period of time necessary for the hydration of the cement and proper hardening of the concrete in accordance with the requirements specified herein.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 30 00 – Cast-In-Place Concrete
- C. Section 03 35 00 – Concrete Finishes

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. ACI 301 – Specifications for Structural Concrete for Buildings
  - 2. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete
  - 3. ACI 305 – Hot Weather Concreting
  - 4. ACI 306 – Cold Weather Concreting
  - 5. ACI 308 – Standard Practice for Curing Concrete
  - 6. ASTM C171 – Standard Specifications for Sheet Materials for Curing Concrete
  - 7. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
  - 8. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

## **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Proposed procedures for protection of concrete under wet weather placement conditions.
  - 2. Proposed normal procedures for protection and curing of concrete.
  - 3. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.
  - 4. Proposed method of measuring concrete surface temperature changes.
  - 5. Manufacturer's literature and material certification for proposed curing compounds.

## **PART 2 – PRODUCTS**

### **2.01 LIQUID MEMBRANE-FORMING CURING COMPOUND**

- A. Clear curing and sealing compound shall be a clear styrene acrylate type complying with ASTM C 1315, Type 1, Class A with a minimum solids content of 30%. Moisture loss shall not be greater than 0.40 kg/m<sup>2</sup> when applied at 300 sq.ft./gal. Manufacturer's certification is required. Acceptable products are Super Diamond Clear VOX by the Euclid Chemical Company, MasteKure CC 300 SB by BASF Master Builder Solutions, and Cure & Seal 30 Plus by Symons Corporation.
- B. Where specifically approved by Engineer, on slabs to receive subsequent applied finishes, compound shall conform to ASTM C 309. Acceptable products are "Kurez DR VOX" or "Kurez W VOX" by the Euclid Chemical Company. Install in strict accordance with manufacturer's requirements.

### **2.02 EVAPORATION REDUCER**

- A. Evaporation reducer shall be BASF, "MasterKure ER 50", or Euclid Chemical "Euco-Bar".

## **PART 3 – EXECUTION**

### **3.01 PROTECTION AND CURING**

- A. All freshly placed concrete shall be protected from the elements, flowing water and from defacement of any nature during construction operations.

- B. As soon as the concrete has been placed and horizontal top surfaces have received their required finish, provision shall be made for maintaining the concrete in a moist condition for at least a 5-day period thereafter except for high early strength concrete, for which the period shall be at least the first three days after placement. Horizontal surfaces shall be kept covered, and intermittent, localized drying will not be permitted.
- C. Walls that will be exposed on one side with either fluid or earth backfill on the opposite side shall be continuously wet cured for a minimum of five days. Use of a curing compound will not be acceptable for applications of this type.
- D. The Contractor shall use one of the following methods to ensure that the concrete remains in a moist condition for the minimum period stated above.
  - 1. Ponding or continuous fogging or sprinkling.
  - 2. Application of mats or fabric kept continuously wet.
  - 3. Continuous application of steam (under 150°F).
  - 4. Application of sheet materials conforming to ASTM C171.
  - 5. If approved by the Engineer, application of a curing compound in accordance with Article 3.04.
- E. The Contractor shall keep absorbent wood forms wet until they are removed. After form removal, the concrete shall be cured by one of the methods in paragraph D.
- F. Any of the curing procedures used in Paragraph 3.01-D may be replaced by one of the other curing procedures listed in Paragraph 3.01-D after the concrete is one-day old. However, the concrete surface shall not be permitted to become dry at any time.

### **3.02 CURING CONCRETE UNDER COLD WEATHER CONDITIONS**

- A. Suitable means shall be provided for a minimum of 72 hours after placing concrete to maintain it at or above the minimum as placed temperatures specified in Section 03 30 00 – Cast-In-Place Concrete, for concrete work in cold weather. During the 72-hour period, the concrete surface shall not be exposed to air more than 20°F above the minimum as placed temperatures.
- B. Stripping time for forms and supports shall be increased as necessary to allow for retardation in concrete strength caused by colder temperatures. This retardation is magnified when using concrete made with blended cements or containing fly ash or ground granulated blast furnace slag. Therefore, curing times and stripping times shall be further increased as necessary when using these types of concrete.

- C. The methods of protecting the concrete shall be approved by the Engineer and shall be such as will prevent local drying. Equipment and materials approved for this purpose shall be on the site in sufficient quantity before the work begins. The Contractor shall assist the Engineer by providing holes in the forms and the concrete in which thermometers can be placed to determine the adequacy of heating and protection. All such thermometers shall be furnished by the Contractor in quantity and type which the Engineer directs.
- D. Curing procedures during cold weather conditions shall conform to the requirements of ACI 306.

### **3.03 CURING CONCRETE UNDER HOT WEATHER CONDITIONS**

- A. When air temperatures exceed 85°F, the Contractor shall take extra care in placing and finishing techniques to avoid formation of cold joints and plastic shrinkage cracking. If ordered by the Engineer, temporary sun shades and/or windbreakers shall be erected to guard against such developments, including generous use of wet burlap coverings and fog sprays to prevent drying out of the exposed concrete surfaces.
- B. Immediately after screeding, horizontal surfaces shall receive an application of evaporation reducer. Apply in accordance with manufacturer's instructions. Final finish work shall begin as soon as the mix has stiffened sufficiently to support the workmen.
- C. Curing and protection of the concrete shall begin immediately after completion of the finishing operation. Continuous moist-curing consisting of method 1 or 2 listed in paragraph 3.01D is mandatory for at least the first 24 hours. Method 2 may be used only if the finished surface is not marred or blemished during contact with the coverings.
- D. At the end of the initial 24-hour period, curing and protection of the concrete shall continue for at least six (6) additional days using one of the methods listed in paragraph 3.01D.
- E. Curing procedures during hot weather conditions shall conform to the requirements of ACI 305.

### **3.04 USE OF CURING COMPOUND**

- A. Curing compound shall be used only where specifically approved by the Engineer. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of five days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.

- B. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time period, and the subsequent appearance of the concrete surface shall not be affected.
- C. The compound shall be applied in accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. Maximum coverage for the curing and sealing compound shall be 300 square feet per gallon for trowel finishes and 200 square feet per gallon for floated or broom surfaces. Maximum coverage for compounds placed where subsequent finishes will be applied shall be 200 square feet per gallon. For rough surfaces, apply in two directions at right angles to each other.

### **3.05 EARLY TERMINATION OF CURING**

- A. Moisture retention measures may be terminated earlier than the specified times only when at least one of the following conditions is met:
  - 1. The strength of the concrete reaches 85 percent of the specified 28-day compressive strength in laboratory-cured cylinders representative of the concrete in place, and the temperature of the in-place concrete has been constantly maintained at 50 degrees Fahrenheit or higher.
  - 2. The strength of concrete reaches the specified 28-day compressive strength as determined by accepted nondestructive methods or laboratory-cured cylinder test results.

**END OF SECTION**

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**SECTION 03 40 00**  
**PRECAST CONCRETE**

**PART 1 – GENERAL**

**1.01 REQUIREMENTS**

- A. The Contractor shall construct all precast concrete items as required in the Contract Documents, including all appurtenances necessary to make a complete installation.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 33 05 61 – Utility Structures
- B. Section 03 21 00 – Reinforcing Steel
- C. Section 03 23 00 – Stressing Tendons
- D. Section 03 30 00 – Cast-in-Place Concrete
- E. Section 03 35 00 – Concrete Finishes
- F. Section 03 39 00 – Concrete Curing
- G. Section 03 60 00 – Grout
- H. Section 05 10 00 – Metal Materials
- I. Section 05 05 13 – Galvanizing
- J. Section 05 05 23 – Metal Fastening
- K. Section 05 59 00 – Bearing Devices and Anchoring

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of other requirements of these Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the end of the Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. ACI 318 – Building Code Requirements for Structural Concrete
  - 3. PCI Standard MNL-116 – Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products

4. PCI Design Handbook

#### **1.04 SUBMITTALS**

- A. The Contractor shall submit the following for review in accordance with Section 01 33 00 – Submittal Procedures.
  1. Shop drawings for all precast concrete items showing all dimensions, locations, and type of lifting inserts, and details of reinforcement and joints.
  2. A list of the design criteria used by the manufacturer for all manufactured, precast items.
  3. Design calculations, showing at least the design loads and stresses on the item, shall be submitted. Calculations shall be signed and sealed by a Professional Engineer registered in the State of Georgia.
  4. Certified reports for all lifting inserts, indicating allowable design loads.
  5. Information on lifting and erection procedures.

#### **1.05 QUALITY ASSURANCE**

- A. All manufactured precast concrete units shall be produced by an experienced manufacturer regularly engaged in the production of such items. All manufactured precast concrete and site-cast units shall be free of defects, spalls, and cracks. Care shall be taken in the mixing of materials, casting, curing and shipping to avoid any of the above. The Engineer may elect to examine the units at the casting yard or upon arrival of the same at the site. The Engineer shall have the option of rejecting any or all of the precast work if it does not meet with the requirements specified herein or on the Drawings. All rejected work shall be replaced at no additional cost to the Owner.
- B. Manufacturer Qualifications: The precast concrete manufacturing plant shall be certified by the Prestressed Concrete Institute, Plant Certification Program, prior to the start of production. Certification is only required for plants providing prestressed structural members such as hollow core planks, double-T members, etc.
- C. Plant production and engineering must be under direct supervision and control of an Engineer who possesses a minimum of five years' experience in precast concrete work.

### **PART 2 – PRODUCTS**

#### **2.01 CONCRETE**

- A. Concrete materials including portland cement, aggregates, water, and admixtures shall conform to Section 03 30 00 – Cast-in-Place Concrete.



- B. For prestressed concrete items, minimum compressive strength of concrete at 28 days shall be 5,000 psi unless otherwise specified. Minimum compressive strength of concrete at transfer of prestressing force shall be 3,500 psi unless otherwise specified.
- C. For non-prestressed concrete items, minimum compressive strength of concrete at 28 days shall be 4000 psi unless otherwise specified.

## **2.02 GROUT**

- A. Grout for joints between panels shall be a cement grout in conformance with Section 03 60 00 – Grout.
- B. Minimum compressive strength of grout at 7 days shall be 3,000 psi.

## **2.03 REINFORCING STEEL**

- A. Reinforcing steel used for precast concrete construction shall conform to Section 03 21 00 – Reinforcing Steel.

## **2.04 PRESTRESSING STRANDS**

- A. Prestressing strands shall be 7-wire, stress-relieved, high-strength strands Grade 250K or 270K in conformance with Section 03 23 00 – Stressing Tendons.

## **2.05 STEEL INSERTS**

- A. Steel inserts shall be in accordance with Section 05 10 00 – Metal Materials.
- B. All steel inserts protruding from or occurring at the surface of precast units shall be galvanized in accordance with Section 05 05 13 – Galvanizing.

## **2.06 WELDING**

- A. Welding shall conform to Section 05 05 23 – Metal Fastening.

## **2.07 BEARING PADS**

- A. Neoprene bearing pads shall conform to Section 05 59 00 – Bearing Devices and Anchoring.
- B. Plastic bearing pads shall be multi-monomer plastic strips which are non-leaching and support construction loads with no visible overall expansion, manufactured specifically for the purpose of bearing precast concrete.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION AND CASTING**

- A. All precast members shall be fabricated and cast to the shapes, dimensions and lengths shown on the Drawings and in compliance with PCI MNL-116. Precast members shall be straight, true and free from dimensional distortions, except for camber and tolerances permitted later in this clause. All integral appurtenances, reinforcing, openings, etc., shall be accurately located and secured in position with the form work system. Form materials shall be steel and the systems free from leakage during the casting operation.
- B. All cover of reinforcing shall be the same as detailed on the Drawings.
- C. Because of the critical nature of the bond development length in prestressed concrete panel construction, if the transfer of stress is by burning of the fully tensioned strands at the ends of the member, each strand shall first be burned at the ends of the bed and then at each end of each member before proceeding to the next strand in the burning pattern.
- D. The Contractor shall coordinate the communication of all necessary information concerning openings, sleeves, or inserts to the manufacturer of the precast members.
- E. Concrete shall be finished in accordance with Section 03 35 00 – Concrete Finishes. Grout all recesses due to cut tendons which will not otherwise be grouted during erection.
- F. Curing of precast members shall be in accordance with Section 03 39 00 – Concrete Curing. Use of a membrane curing compound will not be allowed.
- G. The manufacturer shall provide lifting inserts or other approved means of lifting members.

### **3.02 HANDLING, TRANSPORTING AND STORING**

- A. Precast members shall not be transported away from the casting yard until the concrete has reached the minimum required 28 day compressive strength and a period of at least 5 days has elapsed since casting, unless otherwise permitted by the Engineer.
- B. No precast member shall be transported from the plant to the job site prior to approval of that member by the plant inspector. This approval will be stamped on the member by the plant inspector.
- C. During handling, transporting, and storing, precast concrete members shall be lifted and supported only at the lifting or supporting points as indicated on the shop drawings.
- D. All precast members shall be stored on solid, unyielding, storage blocks in a manner to prevent torsion, objectionable bending, and contact with the ground.

- E. Precast concrete members shall not be used as storage areas for other materials or equipment.
- F. Precast members damaged while being handled or transported will be rejected or shall be repaired in a manner approved by the Engineer.

### **3.03 ERECTION**

- A. Erection shall be carried out by the manufacturer or under his supervision using labor, equipment, tools and materials required for proper execution of the work.
- B. Contractor shall prepare all bearing surfaces to a true and level line prior to erection. All supports of the precast members shall be accurately located and of required size and bearing materials.
- C. Installation of the precast members shall be made by leveling the top surface of the assembled units keeping the units tight and at right angles to the bearing surface.
- D. Connections which require welding shall be properly made in accordance with Section 05 05 23 – Metal Fastening.
- E. Grouting between adjacent precast members and along the edges of the assembled precast members shall be accomplished as indicated on the drawings, care being taken to solidly pack such spaces and to prevent leakage or droppings of grout through the assembled precast members. Any grout which seeps through the precast members shall be removed before it hardens.
- F. In no case shall concentrated construction loads, or construction loads exceeding the design loads, be placed on the precast members. In no case shall loads be placed on the precast members prior to the welding operations associated with erection, and prior to placing of topping (if required).
- G. No Contractor, Subcontractor or any of his employees shall arbitrarily cut, drill, punch or otherwise tamper with the precast members.
- H. Precast members damaged while being erected will be rejected or shall be repaired in a manner approved by the Engineer.

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**PRECAST CONCRETE UTILITY BUILDINGS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install Precast Concrete Utility Buildings as shown on the Drawings and as specified herein.
- B. Work shall include all reinforcements, trim, heating and ventilation units, etc., as shown and required for a complete installation.
- C. Electrical conduit, wire, power distribution equipment, lights, and receptacles are not factory-provided or installed. They field-installed and provided by Division 26.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 33 00 – Submittal Procedures
- B. Section 03 21 00 – Reinforcing Steel
- C. Section 03 40 00 – Precast Concrete

**1.03 SUBMITTALS**

- A. Shop Drawings shall be furnished in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Prepare and submit complete shop drawings for materials to be provided under this section.
  - 2. Submit the sizing calculations for the vent fan.
  - 3. Erection drawings shall be furnished, clearly showing the locations of all components including framed openings, doors, louvers, wall and roof panels, insulation, framing structure and anchoring details for identification and assembly of the structure.
    - a. Drawings shall indicate the locations of the factory-installed equipment mounting strut.
- B. Color charts and samples of architectural finishes shall be provided. All architectural finishes and colors to be selected by Owner.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The prefabricated roof and wall system shall be the EASI-SET precast building as manufactured by Smith Cattleguard Company (Reidsville, NC), Fibrebond (Minden, LA), or equal.

### **2.02 ARCHITECTURAL PRECAST CONCRETE UTILITY BUILDING**

- A. Buildings shall be supplied and installed by the same manufacturer and have inside dimensions as follows:
  - 1. 10'-0" x 14'-0" x 10'-0" high
- B. Buildings shall consist of a prefabricated modular load-bearing roof and prefabricated modular walls to be erected on a bedding of at least eight (8) inches of crushed stone where shown on the Drawings.
- C. Installation shall include all necessary anchors and equipment to secure the building and to ensure that the joints between the walls and slabs are watertight.
- D. Buildings and accessories shall comply with the requirements of the applicable portions of the Georgia State Minimum Standard Building Code and ANSI Specifications. Materials of construction shall conform to the applicable requirements of Section 03 21 00 – Reinforcing Steel and Section 03 40 00 – Precast Concrete.
- E. The modular load-bearing roof shall be capable of supporting a live load of 35 psf and span the required distance without intermediate supports. Design wind loading shall be 27 psf. Roof shall have a minimum 3" overhang on all sides and be sloped a minimum of 1 inch for drainage.
- F. Hollow Metal Door
  - 1. Buildings shall have a 3'-0" x 6'-8" x 1-3/4" steel door supplied by the building manufacturer and located as shown on the Drawings.
    - a. Steel doors shall have at a minimum, 18-gauge steel face and 16-gauge steel frames. Doors and frames shall be reinforced, stiffened, sound deadened, and insulated with foam-type core, completely filling the inside of the door, and laminated to the inside faces of the face sheets. Core material shall have capillary rating of zero.
    - b. Doors and frames shall be bonderized over galvanized surface and then be shop painted with a baked-on rust-inhibitive primer. Finish coatings shall consist of one 5 mil (minimum dry film thickness) coat of Tnemec Series 66

epoxy polyamide and one 5 mil (minimum dry film thickness) coat of Tnemec Series 70 or 71 aliphatic polyurethane, or equal.

- c. Any scratches, abrasions, or any damage to painted galvanized surfaces shall be cleaned and touched-up with a field application of paint as used in the shop.
2. All hollow metal doors, frames, anchors, and steel accessories shall be galvanized by the hot dipped process. The coating shall be commercial class, weighing not less than 1.25 oz. per square foot in accordance with ASTM A 525. The zinc shall be applied in such a manner as to provide a ductile coating that is tightly bonded to both sides of the base metal. Galvanizing shall occur after all accessory work is completed.
3. All hollow metal doors and frames shall be mortised, reinforced, and drilled and tapped for hinges, lock strikes, and all other hardware at the factory. Drilling and tapping for surface hardware shall be done by the building manufacturer.
  - a. Doors shall be furnished with Sargent All Purpose Dormitory or Store Room Locks No. 18-7725, or equal. Lock trim shall be stainless steel. Lock cylinders shall be removable, and all locks shall be operated by the same key.
  - b. Hinges shall be Stanley Model FBB199 stainless steel, or equal. A minimum of three bolts shall be provided per door leaf.
  - c. Doors shall be furnished with stops and holders, Fenestra #9493, H.B. Ives #446B26D, or equal.
  - d. Weatherproofing shall be mounted in the corner of the door frame and shall be ASW 225 by Durable Products, 114 PFPS by Pemko, or equal.
4. Doors and fixed hollow metal panels shall be full flush design, stretcher leveled with no joints or seams in faces. Full length edge or mechanical interlocks shall be provided. Top and bottom of doors shall be of flush design. Doors shall swing out and the fixed hollow metal panels shall have a weather sealed cap or closure.
- G. Buildings shall be furnished with two vents 7" H x 18" W. The vents shall be constructed of 12.5 gauge anodized aluminum and shall be located in the center of the wall opposite the door with one approximately 12 inches from the ceiling and the other 12 inches above the floor.
- H. The location, size, and accessories of all openings and attachments for all trades shall be coordinated by the Contractor and shall be as shown on the Drawings as required for a complete installation.

## **2.03 ACCESSORIES**

### **A. Ventilation**

1. Provide an exhaust fan that is corrosion resistant and equipped with front and rear guards and automatic backdraft damper. Locate the fan as far as practical away from the intake louver.
2. Size the vent fan to remove the heat gain from the building envelope plus the heat gain from the electrical equipment (4,000 BTU/HR) . The vent fan shall be rated for 460 VAC, 3-phase connection.
3. Provide framed openings for the exhaust fan and louver as required to properly support the fan. Flashing and all accessories shall be provided to assure a weathertight installation.
4. Provide an automatic thermostat controller. The thermostat will be wired with a hand-off-auto selector switch on the door of motor starter (provided by Division 26).
5. Factory-install the electric unit heater where indicated on the Drawings.

### **B. Heating**

1. Provide a U.L. Listed electric unit heater rated 1,500W, 480VAC, 3-phase. The heater shall have an integral, adjustable thermostat controller.
2. Factory-install the electric unit heater where indicated on the Drawings.

### **C. Preparation for Mounting Equipment to Walls**

1. Provide factory-installed strut anchored to the walls and ceiling for the surface mounting of electrical panels, devices, and light fixtures. Coordinate locations and anchorage requirements with the Contractor.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. All items specified herein shall be installed where indicated on the Drawings, or as directed by the Engineer.

**END OF SECTION**



## SECTION 03 60 00

### GROUT

#### PART 1 – GENERAL

##### 1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all grout used in concrete work and as bearing surfaces for base plates, in accordance with the Contract Documents.

##### 1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

##### 1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  1. CRD-C 621 – Corps of Engineers Specification for Non-shrink Grout
  2. ASTM C 33 – Standard Specification for Concrete Aggregates
  3. ASTM C 109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm cube Specimens)
  4. ASTM C 531 – Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts and Monolithic Surfacing
  5. ASTM C 579 – Test Method for Compressive Strength of Chemical-Resistant Mortars and Monolithic Surfacing
  6. ASTM C 827 – Standard Test Method for Early Volume Change of Cementitious Mixtures
  7. ASTM C 1107 – Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nonshrink)

##### 1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.

1. Certified test results verifying the compressive strength and shrinkage and expansion requirements specified herein.
2. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of grout used in the work.

## **1.05 QUALITY ASSURANCE**

### **A. Field Tests**

1. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications. The specimens will be made by the Engineer or its representative.
  - a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days and any additional time period as appropriate.
  - b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time period as appropriate.
2. The cost of all laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Engineer in obtaining specimens for testing. The Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the specifications. The Contractor shall supply all materials necessary for fabricating the test specimens, at no additional cost to the Owner.
3. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

#### **A. Cement Grout**

1. Cement grout shall be composed of Portland Cement and sand in the proportion specified in the Contract Documents and the minimum amount of water necessary

to obtain the desired consistency. If no proportion is indicated, cement grout shall consist of one part Portland Cement to three parts sand. Water amount shall be as required to achieve desired consistency without compromising strength requirements. White Portland Cement shall be mixed with the Portland Cement as required to match color of adjacent concrete.

2. The minimum compressive strength at 28 days shall be 4000 psi.
3. For beds thicker than 1-1/2 inch and/or where free passage of grout will not be obstructed by coarse aggregate, 1-1/2 parts of coarse aggregate having a top size of 3/8 inch should be added. This stipulation does not apply for grout being swept in by a mechanism. These applications shall use a plain cement grout without coarse aggregate regardless of bed thickness.
4. Sand shall conform to the requirements of ASTM C33.

B. Non-Shrink Grout

1. Non-shrink grout shall conform to CRD-C 621 and ASTM C 1107, Grade B or C when tested at a max. fluid consistency of 30 seconds per CDC 611/ASTM C939 at temperature extremes of 45°F and 90°F and an extended working time of 15 minutes. Grout shall have a min. 28-day strength of 7,000 psi. Non-shrink grout shall be, "Euco N-S" by the Euclid Chemical Company, "Sikagrout 212" by Sika Corporation, "Conspec 100 Non-Shrink Non-Metallic Grout" by Conspec, "Masterflow 555 Grout" by BASF Master Builder Solutions.

C. Epoxy Grout

1. Epoxy grout shall be "Sikadur 32 Hi-Mod" by Sika Corporation, "Duralcrete LV" by Tamms Industries, or "Euco #452 Series" by Euclid Chemical, "MasterEmaco ADH 1090 RS" by BASF Master Builder Solutions.
2. Epoxy grout shall be modified as required for each particular application with aggregate per manufacturer's instructions.

D. Epoxy Base Plate Grout

1. Epoxy base plate grout shall be "Sikadur 42, Grout-Pak" by Sika Corporation, or "Masterflow 648" by BASF Master Builder Solutions.

## 2.02 CURING MATERIALS

- A. Curing materials shall be as specified in Section 03 39 00, Concrete Curing for cement grout and as recommended by the manufacturer for prepackaged grouts.

## **PART 3 – EXECUTION**

### **3.01 GENERAL**

- A. The different types of grout shall be used for the applications stated below unless noted otherwise in the Contract Documents. Where grout is called for in the Contract Documents which does not fall under any of the applications stated below, non-shrink grout shall be used unless another type is specifically referenced.
  - 1. Cement grout shall be used for grout toppings and for patching of fresh concrete.
  - 2. Non-shrink grout shall be used for grouting beneath base plates of structural metal framing.
  - 3. Epoxy grout shall be used for bonding new concrete to hardened concrete.
  - 4. Epoxy base plate grout shall be used for precision seating of base plates including base plates for all equipment such as engines, mixers, pumps, vibratory and heavy impact machinery, etc.
- B. New concrete surfaces to receive cement grout shall be as specified in Section 03 35 00, Concrete Finishes, and shall be cleaned of all dirt, grease and oil-like films. Existing concrete surfaces shall likewise be cleaned of all similar contamination and debris, including chipping or roughening the surface if a laitance or poor concrete is evident. The finish of the grout surface shall match that of the adjacent concrete. Curing and protection of cement grout shall be as specified in Section 03 39 00, Concrete Curing.
- C. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.
- D. The Contractor, through the manufacturer of a non-shrink grout and epoxy grout, shall provide on-site technical assistance upon request, at no additional cost to the Owner.

### **3.02 CONSISTENCY**

- A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable but will not flow.

### **3.03 MEASUREMENT OF INGREDIENTS**

- A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurement shall not be allowed.
- B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

### **3.04 GROUT INSTALLATION**

- A. Grout shall be placed quickly and continuously, shall completely fill the space to be grouted and be thoroughly compacted and free of air pockets. The grout may be poured in place, pressure grouted by gravity, or pumped. The use of pneumatic pressure or dry-packed grouting requires approval of the Engineer. For grouting beneath base plates, grout shall be poured from one side only and thence flow across to the open side to avoid air-entrapment.

**END OF SECTION**

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**SECTION 04 05 13**  
**MORTAR AND MASONRY GROUT**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and specified herein.
- B. Principal items of work include:
  - 1. Mortar for unit masonry work.
  - 2. Grout for grouting masonry.
  - 3. Mortar for pointing and touchup.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 04 05 23 – Masonry Accessories
- B. Section 04 20 00 – Unit Masonry

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of the Specifications, the Work shall conform to the applicable requirements of the following documents:
  - 1. ASTM C91 – Standard Specification for Masonry Cement
  - 2. ASTM C144 – Standard Specification for Aggregate for Masonry Mortar
  - 3. ASTM C150 – Standard Specification for Portland Cement
  - 4. ASTM C207 – Standard Specification for Hydrated Lime for Masonry Purposes
  - 5. ASTM C270 – Standard Specification for Mortar for Unit Masonry
  - 6. ASTM C476 – Standard Specification for Grout for Masonry
  - 7. ASTM C979 – Pigments for Integrally Colored Concrete
  - 8. ASTM C1019 – Standard Methods of Sampling and Testing Grout
  - 9. ACI 530.1/ASCE 6 – Specification for Masonry Structures

#### **1.04 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
  - 1. Manufacturer's data and mixing instructions for each product.
  - 2. Certificate of compliance with these specifications for each material specified below.
  - 3. Test reports.
  - 4. Samples of colored masonry mortar.

#### **1.05 DELIVERY AND STORAGE**

- A. Deliver materials in manufacturer's original containers, bearing labels indicating product and manufacturer's name.
- B. Store cementitious materials in waterproof locations to prevent damage by elements. Reject containers showing evidence of damage.
- C. Store aggregates in separate bins to prevent intrusion of foreign particles. Do not use bottom 6 inches of sand or other aggregate stored in contact with the ground.

### **PART 2 – PRODUCTS**

#### **2.01 ACCEPTABLE MANUFACTURERS**

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
  - 1. LaFarge, Reston, VA
  - 2. Lehigh Cement Company, Allentown, PA
  - 3. Holcim, Inc., Dundee, MI

#### **2.02 MATERIALS**

- A. Mortar and Grout Materials
  - 1. Portland Cement: ASTM C-150, Type I above grade and Type II below grade.
  - 2. Hydrated lime: ASTM C-207, Type "S".



3. Sand: Clean, coarse, free of loam, salt, organic and foreign matter and conforming to ASTM C-144.
4. Coarse and fine aggregates for grout: ASTM C-404.
5. Masonry Cement: ASTM C 91, Type S and meet the following criteria:
  - a. Prepackaged masonry cement shall contain Portland Cement, hydrated lime and plasticizing admixtures or hydraulic hydrated lime. Masonry cements which contain other materials, including ground limestone, ground slag, or other cementitious and non-cementitious materials, are not acceptable.
6. Water - clean, fresh, potable and free from injurious amounts of oil, acids, alkalies, salts, organic matter or other deleterious substances.

B. Admixtures

1. Do not use calcium chloride.
2. Provide water repellant admixture in mortar used for architectural concrete masonry units. Admixture shall be compatible with ACMU water repellant admixture.
3. Do not use admixtures, without written approval of Engineer.

C. Mortar pigment

1. Natural or synthetic iron oxide and chromium oxides meeting the requirements of ASTM C979.
2. Pigment shall not exceed 10% of the weight of Portland cement. Carbon black shall not exceed 2% of Portland cement.
3. Color shall be selected by the Owner from the manufacturer's full range of colors.

## **2.03 GROUT AND MORTAR MIXES**

A. Masonry mortar shall be Type "S" according to ASTM C-270. Proportions for masonry mortar shall be one of the following:

1. Proportions by volume: 1 part Portland cement to 1/4 - 1/2 parts hydrated lime, and aggregate volume of not less than 2-1/4 or more than 3 times the sum of the volumes of cement and lime.
2. Proportions by volume: 1/2 part Portland cement to 1 part masonry cement, and aggregate volume of not less than 1-1/4 or more than 3 times the sum of the volumes of cement and lime.

- B. Proportions for pointing mortar.
  - 1. Proportions by volume: 1 part Portland cement to 1/4 part hydrated lime and 2 parts extra fine sand.
- C. Masonry Grout shall conform to the requirements of ASTM C 476 and ACI 530.1/ASCE 6, strength of grout, tested in accordance with ASTM C 1019 shall be equal to f'm as specified in Section 04 20 00 – Unit Masonry, but not less than 2,000 psi.
  - 1. Test grout for every 5,000 square feet of masonry, with a minimum of one test per structure.

## **PART 3 – EXECUTION**

### **3.01 FIELD MORTAR MIXING**

- A. Mixing shall be by mechanically operated batch mixer. Entirely discharge before recharging. Mix sand, lime, cement and admixtures dry for two (2) minutes minimum, add water and mix for three (3) minutes minimum. Control batching procedures by measuring materials by volume. Measurement by shovel count shall not be permitted. Mix mortar with less water than the maximum amount, consistent with workability, to provide near maximum tensile bond strength. Mix only quantity that can be used before initial set, or within the first one-half hour.
- B. Mixers, wheel barrows, mortar boards, etc., shall be kept clean.
- C. Retempering of mortar will not be permitted and mortar allowed to stand more than one (1) hour shall not be used.

### **3.02 INSTALLATION**

- A. Install mortar and grout in accordance with ACI 530.1/ASCE 6.

### **3.03 REPOINTING MORTAR**

- A. Prehydrate the mortar by mixing ingredients together dry, and then add only enough water to make a damp, stiff mix that will retain its form when pressed into a ball. After one to two hours, add water to bring it to the proper consistency.

**END OF SECTION**

**SECTION 04 05 23**  
**MASONRY ACCESSORIES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and specified herein.
- B. Principal items of work include:
  - 1. Metal joint reinforcement for masonry.
  - 2. Accessories for masonry construction.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 04 05 13 – Mortar and Masonry Grout
- B. Section 04 20 00 – Unit Masonry

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of these specifications, Work shall conform to the applicable requirements of the following documents:
  - 1. ASTM A1064/1064M – Standard Specification for Carbon Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
  - 2. ASTM A153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
  - 3. ASTM A 951 – Standard Specification for Steel Wire Masonry Joint Reinforcement
  - 4. ASTM D1056 – Standard Specification for Flexible Cellular Materials - Sponge or Extruded Rubber
  - 5. ACI 530.1/ASCE 6 – Specifications for Masonry Structures

**1.04 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
  - 1. Provide manufacturer's complete product data.

2. Provide manufacturer's certification attesting compliance of material and source of each material specified below.

## **PART 2 – PRODUCTS**

### **2.01 ACCEPTABLE MANUFACTURERS FOR MASONRY REINFORCEMENT**

- A. Subject to compliance with the Specifications, provide products manufactured by the following:
  1. AA Wire Products, Company, Chicago, IL
  2. Dur-O-Wal, Inc., Arlington Heights, IL
  3. Heckmann Building Products, Inc., Chicago, IL.
  4. Holman and Barnard, Inc., Hauppauge, NY.

### **2.02 MATERIALS**

- A. Multi Wythe Joint Reinforcement
  1. Steel ladder type reinforcement conforming to ASTM A 951 with adjustable pintel and eye assembly; 3/16 inch side rods and 9 gauge continuous cross rods; manufactured with wire conforming to ASTM A1064/1064M, with widths 2-inches less than nominal wall thickness. Provide seismic clip with 9 gauge continuous wire.
- B. Single Wythe Joint Reinforcement
  1. Steel ladder type reinforcement conforming to ASTM A 951 with 3/16 inch side rods and 9 gauge continuous cross rods; manufactured with wire conforming to ASTM A1064/1064M, with widths 2-inches less than nominal wall thickness.
- C. Anchors: Cast into concrete or weld to steel.
  1. Dovetail Slot shall be 1 inch back by 1 inch deep by 5/8 inch throat, 22 gauge, foam filled.
  2. Dovetail Anchor - accessory for anchoring triangular flexible tie to dovetail slot, shall be 12 gauge by 1 inch wide 1/2 inch long dovetail section.
  3. Wire/Strap Anchor - 1/4 inch wire or 12 gauge x 3/4 inch x length required, welded or mechanically attached to back up structure.
- D. Ties

1. Triangular Flexible Tie: 3/16 inch wire, sized to suit application.
  2. Adjustable Tie: Pintel and eye full tie; properly sized for application, 3/16 inch cold drawn steel.
- E. Seismic Clip and Continuous Wire
1. Seismic clip shall be impact resistant PVC with retaining ridges to accept continuous wire.
  2. Continuous wire shall be 9 gauge galvanized steel.
- F. Top of Wall Anchor
1. Top of wall anchor shall be a 3/8" diameter rod welded to a 3/16" plate with two anchor holes. Provide a plastic tube to allow vertical deflection.
- G. Finish
1. Reinforcements, anchorages and ties shall be hot dipped galvanized, Class B-2, after fabrication in accordance with ASTM A153.

## **2.03 ACCESSORIES**

- A. Expansion and Joint Filler Material
1. Closed cell neoprene material conforming to ASTM D 1056, with a minimum compressibility of 50%. Horizontal joint filler shall be 1/4 inch thick. Expansion joints shall be a minimum 3/8" thick.
- B. Weep and Vent Holes
1. Open head joints for brick and half-head joints for concrete masonry veneer.
- C. Control Joint
1. Wide flange rapid preformed neoprene or PVC gasket.
- D. Hardware Cloth
1. Waterproof paper backed with 1/2 inch hardware cloth.
- E. Through Wall Flashing
1. Self-sealing, fully adhering composite flashing consisting of 32 mil rubberized asphalt bonded to an 8 mil cross laminated polyethylene film to produce an overall 40 mil thickness.

2. Provide Perm-A-Barrier Wall Flashing by W.R. Grace, Flash-Bond by Wire-Bond or Poly-Barrier Wall Flashing by Polytite Manufacturing Corporation.

F. Cavity Drainage Mat

1. CavClear Masonry Mat by CavClear, Hudson WI. Or approved equal. Description: Fluid conducting, non-absorbent, mold and mildew resistant polymer mesh consisting of 100% recycled polymer with PVC binder. Thickness of actual air space minus tolerances recommended by manufacturer.

## **PART 3 – EXECUTION**

### **3.01 REINFORCEMENT AND ANCHORAGE**

- A. In masonry wall panels, place horizontal joint reinforcement at a vertical spacing of 16 inches on center, unless otherwise noted.
- B. Lap side rods at each end joint a minimum of 6 inches.
- C. Install prefabricated corner and tee assemblies at each wall corner and intersection.
- D. Mitre and butt end joints are prohibited.
- E. Place horizontal joint reinforcement in approximate center of out-to-out wall assembly and assuring a 5/8 inch, minimum, mortar coverage on exterior face and 1/2 inch on interior face.
- F. Adjustable anchor assemblies may be offset no more than that which is stated in manufacturer's published instructions. Pintles may be installed either up or down.
- G. Install horizontal joint reinforcement continuous, terminating only at vertical control joints.
- H. Place masonry joint reinforcement in first and second horizontal joints above and below openings. Extend 24 inches minimum each side of opening.
- I. Place joint reinforcement continuous and at 8 inches on center vertically above roof.
- J. Place reinforcing bars supported and secured against displacement. Maintain position with 1/2 inch to true dimension.
- K. Coordinate and verify that dowels and anchorages embedded in concrete and attached to structural steel members are properly placed.
- L. Provide wall ties for masonry veneer at maximum 16 inches on center vertically and 16 inches on center horizontally. Place at maximum 8 inches on center each way around perimeter of openings, within 12 inches of openings.

- M. Masonry adjacent to steel and concrete columns to be attached to the column with masonry anchors at 16 inches on center. Anchors to be attached to each face of the column which is adjacent to a masonry wall, unless otherwise noted.

### **3.02 DOVETAIL SLOTS AND ANCHORS**

- A. Provide dovetail slots to concrete contractor for placement into the concrete construction. Dovetail slots shall be placed vertically and spaced 16 inches on center horizontally.
- B. Remove slot filler after forms are removed.
- C. Hook dovetail anchor into slots and set in masonry joints at 16 inches on center.

### **3.03 BENDING, CUTTING AND SPLICING REINFORCEMENT**

- A. Make bends and splices in reinforcement only where indicated, or prior-approval by Engineer. Bend reinforcement only when cold, and prior to any placement in construction, forming around a steel pin of diameter at least 6 times the reinforcement size. Cut bars only by approved sawing, shearing or welding methods. Make ends of reinforcement straight, square, clean and free of defects before splicing. Do not heat or weld bends and splices at points of maximum stress. Clip and bend any tie wires as required to direct the ends away from external surfaces of masonry walls.
- B. Where welding is necessary, provide materials and perform welding in accordance with AWS requirements.
- C. All lap splices to be 48 bar diameters, unless otherwise noted.

### **3.04 THROUGH WALL FLASHING**

- A. Clean areas to receive flashing. Surface shall be free of voids, spalled areas, or sharp protrusions. Concrete surfaces shall be cured a minimum of 7 days.
- B. Apply Primer as recommended by manufacturer.
- C. Apply flashing in strict accordance with manufacturer's instructions and recommendations. Sidelaps shall be a minimum of 2½ inches. End laps shall have a 6" minimum lap. Provide end dams at ends of lintels and other interruptions.
- D. Seal flashing where vertical reinforcing penetrates flashing with a mastic approved for use by manufacturer.

### **3.05 CAVITY DRAINAGE MAT**

- A. Install cavity drainage mat in air-space between insulation and masonry veneer construction full height of cavity.

- B. Cavity drainage mat shall be temporarily fastened in accordance with manufacturer's instructions.

**END OF SECTION**



**SECTION 04 20 00**  
**UNIT MASONRY**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and specified work.
1. Principal items of work include:
- a. Exterior masonry wall construction.
  - b. Interior masonry wall construction.
  - c. Installation of masonry reinforcement and accessories.
  - d. Masonry unit lintels.
  - e. Installing dampproofing, insulation, flashing and work required to be built into masonry work.
  - f. Building into masonry work all anchors, inserts, hangers and the like provided under other Sections.
  - g. Pointing and cleaning of exposed masonry surfaces.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 04 05 13 – Mortar and Masonry Grout
- B. Section 04 05 23 – Masonry Accessories

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the Specifications, the Work shall conform to the applicable requirements of the following documents:
- 1. TMS 402/ACI 530/ASCE 5 – Building Code Requirements for Masonry Structures
  - 2. ACI 530.1/ASCE 6 – Specifications for Masonry Structures
    - a. ACI 530.1/ASCE 6, jointly published by the American Concrete Institute and the American Society of Civil Engineers, hereafter referred to as ACI 530.1 shall be considered minimum specifications for all materials, workmanship, methods and techniques for all masonry work.

- b. Obtain a copy of the above Specifications prior to beginning any work in this Section.
3. ASTM C62 – Standard Specification for Building Brick
4. ASTM C90 – Standard Specification for Load-Bearing Concrete Masonry Units
5. ASTM C140 – Standard Methods for Sampling and Testing Concrete Masonry Units
6. ASTM C216 – Standard Specification for Facing Brick
7. ASTM C744 – Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units
8. ANSI A41.1 R70 – Code Requirements for Masonry

#### **1.04 TESTING**

##### **A. Tests**

1. The Owner reserves the right to test materials for compliance with these specifications. Sampling and testing will be done in accordance with the ASTM standard, by an independent testing agency employed by the Owner. Materials that fail to meet requirements are considered defective. Subsequent tests to establish compliance (of the same or new materials) shall be paid for by the Contractor.

#### **1.05 SUBMITTALS**

##### **A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:**

1. Samples of each material to be used showing full range of colors.
2. Manufacturer's specifications and certifications of compliance to the Specifications, including results of tests on masonry units showing such compliance, for each type of masonry. Provide handling, storage, and installation instructions along with protection instructions. Indicate by transmittal that installer has received copies of each instruction.
3. Cold and/or hot weather construction procedures in accordance with ACI 530.1/ASCE 6 sections 2.3.2.2. and 2.3.2.3.
4. Cleaning procedures and cleaner for each masonry type.

#### **1.06 MOCK-UPS**

- A. Build mock-ups at the site, where directed, full thickness and approximately 4 feet x 4 feet, indicating the proposed color range, texture and workmanship for each type of masonry. Obtain Engineer's acceptance of visual qualities of the mock-up before start of masonry work. Do not alter, move or destroy mock-ups until Work is completed and removal is directed by the Engineer.

## **1.07 DELIVERY, STORAGE AND HANDLING**

- A. Deliver materials in the manufacturer's original unbroken, undamaged and unopened packaging with labels bearing the name of the manufacturer and the product. Masonry units and brick shall be factory packaged and strapped, delivered to the site and stored on skids.
- B. Store and handle materials to prevent inclusion of water or foreign matter and to prevent damage of any nature.
- C. Distribute materials on floor slabs to prevent overloading. Designated live loads shown for floor shall not be exceeded.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. Provide special shape, type or size indicated or for application requiring a form, size or finish which cannot be produced from standard masonry units by sawing. Provide solid units where masonry unit is exposed.
- B. Masonry units for fire-rated walls shall comply with Underwriter's Laboratory requirements for fire rating shown on the Drawings.

### **2.02 MATERIALS**

- A. Mortar
  - 1. In accordance with Section 04 05 13 – Mortar and Masonry Grout
- B. Face Brick
  - 1. ASTM C-216, Type FBS, SW. modular as manufactured and distributed by Belden Brick Company, Glen-Gery Corporation, Cherokee Sanford Group, Inc. or equal. Face brick shall be selected and approved by the Owner from samples submitted. Select color from manufacturer's gray and brown color range. Sand finished brick shall not be accepted.
  - 2. Net area compressive strength of brick masonry units shall be a minimum of 3,350 psi when tested in accordance with ASTM C67. Compressive strength of masonry (f'm) shall be a minimum of 1,500 psi in accordance with ACI 530.1 when

these units are used with the mortar specified in Section 04 05 13 – Mortar and Masonry Grout.

#### C. Concrete Masonry Units

1. Provide units conforming to ACI 530.1 unless otherwise specified.
2. Provide light weight units meeting the requirements of ASTM C90 for hollow and solid load bearing CMU.
3. Manufacture units of Portland Cement, conforming to ASTM C-150 and light weight aggregate conforming to ASTM C331 and ASTM C33. Weight of unit shall not exceed 105 lb. per cu. ft. when measured in accordance with provisions of ASTM C140. Units shall be nominally 8 inches x 16 inches x thicknesses shown or as required. Masonry units shall be manufactured not less than 30 days prior to being used and stored under cover until shipment. All units shall have true, sharp edges and corners, free from cracks or other defects. Provide half special sizes and shapes as required by the Drawings or to meet job conditions.
4. Net area compressive strength of concrete masonry units shall be a minimum of 2,000 psi when tested in accordance with ASTM C140. Compressive strength of masonry (f'm) shall be a minimum of 2,000 psi in accordance with ACI 530.1 when these units are used with the mortar specified in Section 04 05 13 – Mortar and Masonry Grout.

#### D. Concrete Masonry Lintels

1. Specially formed units with reinforcing bars and grout fill provided where shown and wherever openings in masonry are indicated without structural steel or other supporting lintels.

#### E. Glazed Architectural Concrete Masonry Units

1. Plane face, colored, satin finished units conforming to ASTM C-744.
2. Concrete masonry unit for glazing: ASTM C-90 for hollow and solid load bearing units.
3. Surface burning Characteristics of Facing: ASTM E-84; flame spread less than 25, fuel contribution zero, smoke density less than 50.
4. Size: Nominal face dimension 8 inches x 16 inches x thickness as required and shown on the Drawings.
5. Colors: Owner to select from manufacturer's complete color selections. Provide a minimum of 60 colors.

6. Acceptable Products: Spectra-Glaze by Burns and Russell Company, Asta-Glaze by Trenwyth Industries, Inc., or equal.

F. Sound Absorptive Concrete Masonry Units

1. 8-inch by 8-inch by 16-inch and Type RSC/RF4 by Sounblox.
2. Units shall meet the requirements of ASTM C90.
3. The fillers shall have metal septa laminated to one side of the fibrous material and installed with the septa facing away from the slots at the factory. Cut filler and septa accurately to size and install as recommended by the Manufacturer.

G. Glass Block

1. Size: 8"x8"x4"
2. Color: Clear.
3. Pattern: None.
4. Acceptable Manufacturers
  - a. J. Weck GmbH u. Company, Arlington Heights, IL
  - b. Pittsburg Corning Corp., Pittsburg, PA.

H. Architectural Concrete Masonry Units

1. Scored smooth and split-face CMU shall be manufactured by firm producing architectural concrete masonry units for a minimum of five years.
2. Units shall conform to ASTM C-90, Type I, normal weight.
3. Provide units with integral water repellent admixture. Absorption shall not exceed 10 lbs per cubic foot.
4. Minimum compressive strength shall be 2700 psi on wet area of a single unit.
5. Color shall be selected from manufacturer full line of colors. Up to two colors shall be selected.

I. Insulated Block System

1. Pre-Insulated specially formed masonry units with individually molded insulation. Units shaped to reduce cross-web thermal conductance. CMU and Insulation shall be configured to provide a near continuous insulated plane within wall.

- a. Provide light weight units conforming to ASTM C90. Weight of unit shall not exceed 105 lb. per cu. ft. when measured in accordance with provisions of ASTM C140.
- b. Individually molded expandable polystyrene, conforming to ASTM C578.
- c. Reinforced insulated block system wall thermal resistance shall be R-10, minimum.
- d. Exterior finish shall be split faced.
- e. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
  - 1) Korfil Hi-R Masonry Wall System, by Concrete Block Insulating Systems, West Brookfield, MA.
  - 2) Omni Block Insulated Concrete Block, by Omni Block, Las Vegas, NV.
  - 3) Or Approved Equal.

## **PART 3 – EXECUTION**

### **3.01 GENERAL**

- A. Examine areas and conditions under which masonry is to be installed and notify the Engineer in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.
- B. Do not wet concrete masonry units.
- C. Brick having absorption rates in excess of 0.025 oz. per square inch per minute (as determined per ASTM C 67) shall be wetted sufficiently so that the rate of absorption, when brick is laid, does not exceed this amount.
- D. Clean reinforcing, removing loose rust, ice or other coatings from bars, before placement.
- E. Thickness of cavity and composite walls, and other masonry construction shall be the full thickness shown. Build single wythe walls to the actual size of masonry units.
- F. Build chases and recesses as shown and as required for the work of other trades.
- G. Build other work into masonry work as shown, fitting masonry units around other work and grouting to assure anchorage.

- H. Cut masonry units with motor driven saw designed to cut masonry with clean, sharp, unchipped edges. Cut units as required to provide pattern shown or specified, and to fit adjoining work neatly.
- I. Cold and hot weather construction.
  - 1. No masonry shall be erected when ambient temperature has dropped below 45°F unless it is rising and at no time when it has dropped below 40°F. Provisions shall be made for heating and drying of materials, and the complete work shall be protected in accordance with the ACI 530.1/ASCE 6 Section 2.3.2.2. Masonry shall not be laid with ice or frost on its surfaces, and no masonry shall be laid on frozen work. Any work which freezes before the mortar has set shall be removed and replaced at the Contractor's own expense. Do not use any admixtures or antifreeze in the mortar.
  - 2. When the temperature is above 100°F or 90°F with a wind velocity greater than 8 mph, mortar beds shall be spread no more than 4 feet ahead of masonry and masonry units shall be set within one minute of spreading mortar.

### **3.02 CONSTRUCTION TOLERANCES**

- A. Variation from plumb: For vertical lines and surfaces of columns, walls and arises do not exceed 1/4" in 10', or 3/8" in a story height not to exceed 20', nor 1/2" in 40' or more. For external corners, expansion joints, control joints and other conspicuous lines, do not exceed 1/4" in any story or 20' maximum, nor 1/2" in 40' or more. For vertical alignment of head joints do not exceed plus or minus 1/4" in 10', 1/2" maximum.
- B. Variation from level: For bed joints and lines of exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines do not exceed 1/4" in any bay or 20' maximum, nor 1/2" in 40' or more. For top surface of bearing walls do not exceed 1/8" between adjacent floor elements in 10' or 1/16" within width of a single unit.
- C. Variation of Linear Building Line: For position shown on plan and related portion of columns, walls, and partitions, do not exceed 1/2" in any bay or 20' maximum, nor 3/4" in 40' or more.
- D. Variation in Cross Sectional Dimensions: For columns and thickness of walls, from dimensions shown, do not exceed minus 1/4" nor plus 1/2".
- E. Variation in Mortar Joint Thickness: Do not exceed bed joint thickness indicated by more than plus or minus 1/8", with a maximum thickness limited to 1/2". Do not exceed head joint thickness indicated by more than plus or minus 1/8".

### **3.03 LAYING MASONRY WALLS**

- A. Layout walls in advance for accurate spacing of surface bond patterns, with uniform joint widths and to properly locate openings, movement-type joints, returns and offsets. Avoid

the use of less-than-half size units at corners, jambs, and wherever possible at other locations.

- B. Lay-up walls to comply with specified construction tolerances, with courses accurately spaced and coordinated with other work.
- C. Pattern Bond: Lay exposed masonry in the bond pattern shown or, if not shown, lay in running bond with vertical joint in each course centered on units in courses above and below.
- D. Stopping and Resuming Work: Rack back 1/2 unit length in each course; do not tooth. Clean exposed surfaces of set masonry, wet units lightly, and remove loose masonry units and mortar prior to laying fresh mortar.
- E. Cover top of walls at the end of each day. Protect wall from water infiltration from the top until wall is capped.
- F. Built-In Work: As work progresses, build-in items specified under this and other sections of these Specifications. Fill in solidly with masonry around built-in items.
  - 1. Fill space between hollow metal frames and masonry solidly with mortar, unless otherwise indicated.
  - 2. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of hardware cloth in the joint below and rod grout into core.
  - 3. Fill cores in hollow masonry units with grout 3 courses (24") under bearing plates, beams, lintels, posts and similar items, unless otherwise noted.
  - 4. Seal masonry tight around wall penetrations such as beams, joists, pipes, ducts, and conduit by cutting masonry units to fit as tightly as possible, then closing final gap all around with mortar, or joint filler and caulking as necessary.

### **3.04 MORTAR BEDDING AND JOINTING**

- A. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not slush head joints.
- B. Lay hollow concrete masonry units with full mortar coverage on horizontal and vertical face shells; also bed webs with mortar in starting courses on footing or floors, and where adjacent cells are to be reinforced or filled with grout. For starting courses where cells are not grouted, spread full mortar bed including areas under cells.
- C. Maintain joint widths of 3/8", except for minor variations required to maintain bond alignment.



- D. Tooling: Joints shall be tooled to a uniform concave joint. Head joints first and then the bed joints.
- E. Remove masonry units disturbed after laying; clean and reset in fresh mortar. Do not pound corners and jambs to shift adjacent stretcher units which have been set in position. If adjustments are required, remove units, clean and reset in fresh mortar.

### **3.05 JOINT REINFORCING**

- A. Use continuous horizontal joint reinforcement installed in horizontal mortar joints not more than 16" o.c. vertically.
- B. Parapets: Use continuous horizontal joint reinforcement installed in horizontal joints at 8" o.c. vertically.
- C. Reinforced masonry openings greater than 12" wide, with horizontal joint reinforcing placed in 2 horizontal joints immediately above the lintel and immediately below the sill. Extend reinforcements 2'-0" beyond jambs of the opening except at control joints.
- D. Cut or interrupt joint reinforcement at control and expansion joints, unless otherwise indicated.
- E. Provide continuity at corners and wall intersections by use of prefabricated "L" and "T" sections. Cut and bend reinforcement units as directed by manufacturer for continuity at returns, offsets, pipe enclosures and other special conditions.
- F. Intersecting Load-bearing Walls: Provide rigid steel anchors at not more than 2'-0" o.c. vertically. Embed ends in mortar-filled cores.
- G. Non-loadbearing Interior Partitions: Build full height of story to underside of solid floor or structure above, unless shown otherwise. Fill joint with mortar after dead load deflection of structure above approaches final position.

### **3.06 CAVITY WALLS**

- A. Keep cavity clean of mortar droppings and other materials during construction. Strike joints facing cavity, flush.
- B. Tie exterior wythe to back-up wythe of masonry with horizontal joint reinforcement at 16" o.c. vertically.
- C. Coordinate placement of dampproofing and insulation board with work to ensure there are no gaps or air spaces between pieces of insulation board.
- D. Weep joints shall be placed in exterior wythe of cavity wall, spaced a maximum of 32" o.c. horizontally, immediately above ledges, at lintels over openings, and as shown.

### **3.07 CAVITY WALL INSULATION**

- A. Provide and install insulation as shown and as specified in Section 07 21 00 – Building Insulation.

### **3.08 CONTROL AND EXPANSION JOINTS**

- A. General: Provide vertical and horizontal expansion, control and isolation joints in masonry where shown. Where not shown provide vertical control joints in concrete masonry units at 40 feet on center maximum or as recommended by the masonry unit manufacturer. Build-in related items as the masonry work progresses.

### **3.09 LINTELS**

- A. Install galvanized steel lintels where indicated.
- B. Provide masonry lintels where shown and wherever openings of more than 8" for brick size units and 1'-4" for block size units are shown without structural steel or other supporting lintels. Provide precast or poured-in-place masonry lintels. Cure precast lintels before handling and installation. Temporarily support formed-in-place lintels.
- C. For hollow concrete masonry unit walls, use specially formed "U"-shaped lintel units with reinforcement bars placed as shown and filled with grout.
- D. Provide minimum bearing of 8" at each jamb.

### **3.10 FLASHING**

- A. Provide flashing as shown and as specified in Section 07 60 00 – Flashing and Sheet Metal.

### **3.11 REINFORCED UNIT MASONRY**

- A. Vertical reinforcement shall be held in place by means of frames or other suitable means. Place horizontal joint reinforcement as masonry work progresses. Provide minimum clear distance between longitudinal bars equal to nominal diameter of bar. Minimum thickness of mortar or grout between masonry and reinforcement shall be 1/4", except 6 gage or smaller wires may be laid in 3/8" mortar joints. Collar joints which contain both horizontal and vertical reinforcement shall have a minimum width of 1/2" larger than the diameter of the horizontal and vertical reinforcement.
- B. Bar splices shall be contact lap splices. Length of splice shall be a minimum of 24" for #4 bars and 30" for #5 bars.
- C. Low lift grouting shall be used when grout space is less than 2" in width. Place grout at maximum intervals of 24" in lifts of 6 to 8 inches as the work progresses. Cores to be grouted shall be clean of mortar, mortar dropping and debris. Agitate grout to assure complete filling and coverage of reinforcement. Hold grout 1-1/2 inches below to top of masonry if work is discontinued for more than an hour.

- D. High lift grouting may be used when the grout space is greater than 2". Grout shall not be placed in lifts greater than 4 feet. Grout core shall be kept clean of mortar, mortar dripping and debris. Provide cleanout holes as required for inspection and cleaning. Replace cleanout plugs after inspection and acceptance. Do not place grout until entire wall has been in place a minimum of 3 days. Hold grout 1-1/2 inches below top of masonry if work is discontinued for more than an hour.
- E. Forms and shoring shall be substantial and tight to prevent leakage of mortar or grout. Brace and shore forms to maintain position and shape. Do not remove forms or shoring until masonry gains enough strength to sufficiently carry its own weight and any other loads, temporary or permanent, placed on it during construction.

### **3.12 PROTECTION OF WORK**

- A. Exposed masonry surfaces shall be protected from staining. Tops of wall shall be covered with nonstaining waterproof coverings when work is not in progress. Installed material shall be secure in high winds.
- B. Protection shall be provided for all openings in the walls to prevent damage to sills, jambs, etc., from all causes. Aluminum or steel frames and other finish materials shall be protected from damage during masonry work.

### **3.13 REPAIR, POINTING AND CLEANING**

- A. Remove and replace masonry units which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install fresh mortar or grout, pointed to eliminate evidence of replacement.
- B. Pointing of Masonry: At the completion of the masonry work, all holes in exposed masonry shall be pointed. Defective joints shall be cut out and tuckpointed solidly with mortar. Pointing and tuckpointing shall be done with a pre-hydrated mortar. The mortar cement shall be controlled so that, after curing of the mortar, no difference in texture or color exists with that of adjacent masonry.
- C. Masonry Cleaning: While laying masonry units, good workmanship and job housekeeping practices shall be used so as to minimize the need for cleaning the masonry work. Protect the base of the wall from mud splashes and mortar droppings. The technique for laying masonry shall be such that mortar does not run down the face of the wall or smear onto the face.
  - 1. After the joints are tooled, cut off mortar failings with the trowel and brush excess mortar burrs and dust from the face of the masonry, use a bricklayer's brush made with medium soft hair.
  - 2. Remove all large mortar particles with a hardwood scraper.

3. If, after using the above outlined techniques, additional cleaning of the walls is found necessary, allow the walls to cure one month prior to initiating further cleaning processes.
- D. Clean masonry to comply with the masonry manufacturer's directions and applicable NCMA "Tek" bulletins or BIA technical notes and the following requirements.
1. Saturate the wall with clean water. The wall shall be thoroughly saturated prior to and at the time the cleaning solution is applied.
  2. Clean masonry with an approved cleaning solution for each type of masonry applied with a brush, starting at the top of the wall. Approved cleaners shall be composed primarily of detergents, wetting agents, buffering agents, and a maximum of 10% muriatic acid. Do not use acids on masonry surfaces that will be damaged by use of an acid cleaner. The use of any of the above cleaning agents shall first be approved in writing by the manufacturer of the masonry being cleaned and the Engineer. The concentration, method of application of the cleaning solution, and method of scraping shall be as outlined on the container by the manufacturer.
  3. High pressure water and sandblasting shall not be used for cleaning except with the recommendation of the masonry manufacturer and the written approval of the Engineer.
  4. Immediately after cleaning a small area, the wall shall be rinsed thoroughly with quantities of water.
  5. Protect adjacent surfaces and materials during masonry cleaning operations.
  6. After the walls are cleaned, take the necessary precautions to ensure that other contractors and subcontractors do not damage or soil the walls. Mud protection around the base of walls shall be left in place until the grading work is done.

**END OF SECTION**

**SECTION 05 05 13**  
**GALVANIZING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Where galvanizing is called for in the Contract Documents, the galvanizing shall be performed in accordance with the provisions of this Section unless otherwise noted.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Further requirements for galvanizing specific items may be included in other Sections of the Specifications. See section for the specific item in question.

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Amendments to the International Building Code – 2018 Edition
  - 2. ASTM A123 – Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
  - 3. ASTM A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
  - 4. ASTM A653 – Standard Specification for Steel Sheet, Zinc Coated (Galvanized), or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
  - 5. ASTM A924 – Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
  - 6. ASTM A780 – Standard Practice of Repair of Damaged Hot-Dip Galvanized Coatings
  - 7. ASTM F2329 – Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Certification that the item(s) are galvanized in accordance with the applicable ASTM standards specified herein. This certification may be included as part of any material certification that may be required by other Sections of the Specifications.

## **PART 2 – PRODUCTS**

### **2.01 GALVANIC COATING**

- A. Material composition of the galvanic coating shall be in accordance with the applicable ASTM standards specified herein.

## **PART 3 – EXECUTION**

### **3.01 FABRICATED PRODUCTS**

- A. Products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strips, 1/8 inch thick and heavier which are to be galvanized shall be galvanized in accordance with ASTM A123. Products shall be fabricated into the largest unit which is practicable to galvanize before the galvanizing is done. Fabrication shall include all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, and welding. Components of bolted or riveted assemblies shall be galvanized separately before assembly. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating. The galvanizer shall be a member of American Galvanizers Association.
- B. Components with partial surface finishes shall be commercial blast cleaned prior to pickling.
- C. Sampling and testing of each lot shall be performed prior to shipment from the galvanizer's facility per ASTM A123.

### **3.02 HARDWARE**

- A. Iron and steel hardware which is to be galvanized shall be galvanized in accordance with ASTM A153 and ASTM F2329.

### **3.03 ASSEMBLED PRODUCTS**

- A. Assembled steel products which are to be galvanized shall be galvanized in accordance with ASTM A123. All edges of tightly contacting surfaces shall be completely sealed by welding before galvanizing.
- B. Assemblies shall be provided with vent and drain holes as required by the fabricator. Vent and drain hole sizes and locations shall be included in the structural steel shop

drawings required in Section 05 12 00 – Structural Steel for approval. All vent and drain holes shall be plugged and finished to be flush with and blend in with the surrounding surface. Where water intrusion can occur, the plug shall be carefully melted into the surrounding zinc coating using an appropriate fluxing agent.

### **3.04 METAL DECK**

- A. Unless noted otherwise, metal deck shall be galvanized in accordance with ASTM A653 G60 minimum. In moist environments or as indicated on the Contract Drawings, galvanizing shall meet the requirements of ASTM A653 G90.
- B. Galvanized metal deck shall meet the requirements of ASTM A924.

### **3.05 REPAIR OF GALVANIZING**

- A. Galvanized surfaces that are abraded or damaged at any time after the application of zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with 2 coats of zinc rich paint meeting the requirements of Federal Specification DOD-P-21035A and shall be thoroughly mixed prior to application. Zinc rich paint shall not be tinted. The total thickness of the 2 coats shall not be less than 6 mils. In lieu of repairing by painting with zinc rich paint, other methods of repairing galvanized surfaces in accordance with ASTM A780 may be used provided the proposed method is acceptable to the Engineer.

**END OF SECTION**

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**SECTION 05 05 23**  
**METAL FASTENING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all materials, labor, and equipment required to provide all metal welds and fasteners not otherwise specified, in accordance with the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 13 00 – Stainless Steel
- D. Section 05 12 00 – Structural Steel
- E. Section 05 14 00 – Structural Aluminum

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. AC 193 – Acceptance Criteria for Mechanical Anchors in Concrete Elements
  - 3. AC 308 – Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements
  - 4. ACI 318 – Building Code Requirements for Structural Concrete
  - 5. ACI 355.2 – Qualifications of Post-Installed Mechanical Anchors in Concrete
  - 6. ACI 355.4 – Qualifications of Post-Installed Adhesive Anchors in Concrete
  - 7. AISC 348 – The 2009 RCSC Specification for Structural Joints
  - 8. AISC – Code of Standard Practice
  - 9. AWS D1.1 – Structural Welding Code – Steel

10. AWS D1.2 – Structural Welding Code – Aluminum
11. AWS D1.6 – Structural Welding Code – Stainless Steel
12. Aluminum Association – Specifications for Aluminum Structures
13. ASTM A572/A572M-94C – Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel Grade 50
14. ASTM A36 – Standard Specification for Carbon Structural Steel
15. ASTM A489 – Standard Specification for Eyebolts
16. ASTM A563 – Standard Specifications for Carbon and Alloy Steel Nuts
17. ASTM D1785 – Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe
18. ASTM E488 – Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
19. ASTM F436 – Standard Specification for Hardened Steel Washers
20. ASTM F467 – Standard Specification for Nonferrous Nuts for General Use
21. ASTM F593 – Standard Specification for Stainless Steel Bolts; Hex Cap Screws, and Studs
22. ASTM F594 – Standard Specification for Stainless Steel Nuts
23. ASTM F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
24. ASTM F3125 – Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength, Inch and Metric Dimension

#### **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  1. Shop Drawings providing the fastener's manufacturer and type and certification of the fastener's material and capacity.
  2. Anchor design calculations sealed by a Professional Engineer currently registered in the State of Georgia. Only required if design not shown on Contract Drawings.
  3. A current Evaluation Report shall be submitted for all anchors that will be considered for use on this project.

4. Manufacturer's installation instructions.
5. Copy of valid certification for each person who is to perform field welding.
6. Certified weld inspection reports, when required.
7. Welding procedures.
8. Installer qualifications.
9. Certification of Installer Training.
10. Inspection Reports.
11. Results of Anchor Proof Testing.

#### **1.05 QUALITY ASSURANCE**

- A. Fasteners not manufactured in the United States shall be tested and certification provided with respect to specified quality and strength standards. Certifications of origin shall be submitted for all U.S. fasteners supplied on the project.
- B. Evaluation Report: A current Evaluation Report from an independent testing and evaluation agency (ITEA) shall be submitted for all anchors that will be used on this project. The ITEA producing the evaluation report shall be accredited in accordance with the requirements for ITEA's in ACI 355.2 (for mechanical anchors) or 355.4 (for adhesive anchors). Acceptable ITEA's include but are not necessarily limited to the International Code Council Evaluation Service (ICC-ES) and the International Association of Plumbing and Mechanical Officials Uniform Evaluation Service (IAPMO-UES).
- C. Installer Qualifications: All concrete anchors shall be installed by an Installer with at least three years of experience performing similar installations. Concrete adhesive anchor installer shall be certified as an Adhesive Anchor Installer in accordance with ACI-CRSI Adhesive Anchor Installation Certification Program.
- D. Installer Training: For concrete anchors, conduct a thorough training with the manufacturer or the manufacturer's representative for the Installer on the project. Training shall consist of a review of the complete installation process to include but not be limited to the following:
  1. Hole drilling procedure.
  2. Hole preparation and cleaning technique.
  3. Adhesive injection technique and dispenser training/maintenance.
  4. Concrete adhesive anchor preparation and installation.

5. Proof loading/torquing.
  6. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information
- E. All steel welding shall be performed by welders certified in accordance with AWS D1.1. All aluminum welding shall be performed by welders certified in accordance with AWS D1.2. All stainless steel welding shall be performed by welders certified in accordance with AWS D1.6. Certifications of field welders shall be submitted prior to performing any field welds.
  - F. Welds and high strength bolts used in connections of structural steel will be visually inspected in accordance with Article 3.04.
  - G. The Owner may engage an independent testing agency to perform testing of welded connections and to prepare test reports in accordance with AWS. Inadequate welds shall be corrected or redone and retested to the satisfaction of the Engineer and/or an acceptable independent testing laboratory, at no additional cost to the Owner.
  - H. Provide a welding procedure for each type and thickness of weld. For welds that are not prequalified, include a Performance Qualification Report. The welding procedure shall be given to each welder performing the weld. The welding procedure shall follow the format in Annex E of AWS D1.1 with relevant information presented.
  - I. Special inspections for concrete adhesive anchors shall be conducted in accordance with the manufacturer's instructions and Section 01 45 33 – Special Inspections. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

## **PART 2 – PRODUCTS**

### **2.01 ANCHOR RODS (ANCHOR BOLTS)**

- A. Anchor rods shall conform to ASTM F1554 Grade 55 except where stainless steel or other approved anchor rods are shown on the Drawings. Anchor rods shall have hexagonal heads and shall be supplied with hexagonal nuts meeting the requirements of ASTM A563 Grade A.
- B. Where anchor rods are used to anchor galvanized steel or are otherwise specified to be galvanized, anchor rods and nuts shall be hot-dip galvanized in accordance with ASTM F1554.
- C. Where pipe sleeves around anchor rods are shown on the Drawings, pipe sleeves shall be cut from Schedule 40 PVC plastic piping meeting the requirements of ASTM D1785.

## **2.02 HIGH STRENGTH BOLTS**

- A. High strength bolts and associated nuts and washers shall be in accordance with ASTM F3125. Bolts, nuts and washers shall meet the requirements of RCSC Specification for Structural Joints Using High Strength Bolts”.
- B. Where high strength bolts are used to connect galvanized steel or are otherwise specified to be galvanized, bolts, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A325.

## **2.03 STAINLESS STEEL BOLTS**

- A. Stainless steel bolts shall conform to ASTM F-593 Grade A325 or F1852. All underwater fasteners, fasteners in confined areas containing fluid, and fasteners in corrosive environments shall be Type 316 stainless steel unless noted otherwise. Fasteners for aluminum and stainless steel members not subject to the above conditions shall be Type 304 stainless steel unless otherwise noted.
- B. Stainless steel bolts shall have hexagonal heads with a raised letter or symbol on the bolts indicating the manufacturer and shall be supplied with hexagonal nuts meeting the requirements of ASTM F594. Nuts shall be of the same alloy as the bolts.

## **2.04 CONCRETE ANCHORS**

- A. General
  - 1. Where concrete anchors are called for on the Drawings, one of the types listed below shall be used; except, where one of the types listed below is specifically called for on the Drawings, only that type shall be used. The determination of anchors equivalent to those listed below shall be on the basis of test data performed by an approved independent testing laboratory. There are two types used:
    - a. Mechanical anchors include any of the following anchors:
      - i. Expansion anchors shall be mechanical anchors of the wedge, sleeve, or drop-in type that are set by expanding against the sides of the drilled hole.
      - ii. Screw anchors are mechanical anchors that derive tensile holding strength by the mechanical interlock provided by threads cutting into the concrete during installation. Screw anchors shall be one piece, heavy duty screw anchors with a finished head.
    - b. Adhesive anchors shall consist of threaded rods or bolts anchored with an adhesive system into hardened concrete. Adhesive anchors shall be two part

injection type using the manufacturer's static mixing nozzle and shall be supplied as an entire system.

2. Expansion anchors shall not be used to hang items from above or in any other situations where direct tension forces are induced in anchor.
3. Unless otherwise noted, all concrete anchors which are submerged or are used in hanging items or have direct tension induced upon them, or which are subject to vibration from equipment such as pumps and generators, shall be adhesive anchors.
4. Adhesive anchors shall conform to the requirements of ACI 355.4 or alternately to AC 308. Mechanical anchors shall conform to the requirements of ACI 355.2 or alternately to AC 193. Anchors in Seismic Design Categories C through F shall conform to the International Building Code and ACI 318 Chapter 17 requirements as applicable, including seismic test requirements.
5. Fire Resistance: All anchors installed within fire resistant construction shall either be enclosed in a fire resistant envelope, be protected by approved fire-resistive materials, be used to resist wind and earthquake loads only, or anchor non-structural elements.
6. Engineer's approval is required for use of concrete anchors in locations other than those shown on the Drawings.

B. Concrete Anchor Design:

An anchor design consists of specifying anchor size, quantity, spacing, edge distance and embedment to resist all applicable loads. Where an anchor design is indicated on the Drawings, it shall be considered an engineered design and anchors shall be installed to the prescribed size, spacing, embedment depth and edge distance. If all parts of an anchor design are provided on the Drawings except embedment depth, the anchors will be considered an engineered design and the Contractor shall provide the embedment depth as indicated in Paragraph B.3 unless otherwise directed by the Engineer. Where an anchor design is not indicated by the Engineer on the Drawings, the Contractor shall provide the anchor design per the requirements listed below.

- a. The Contractor shall submit an engineered design with signed and sealed calculations performed by an Engineer currently registered in the State of Georgia. Anchors shall be of a type recommended by the anchor manufacturer for use in cracked concrete and shall be designed by the Contractor in accordance with ACI 318 Chapter 17.
- b. Embedment Depth

- a. Minimum anchor embedment shall be as indicated on the Drawings or determined by the Contractor's engineered design. Although all manufacturers listed are permitted, the embedment depth indicated on the Drawings is based on "Pure 110+ by DeWalt" ESR 3298 issued 7/2017. If the contractor submits one of the other concrete adhesive anchors listed, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.
- b. Where the embedment depth is not shown on the Drawings, concrete anchors shall be embedded no less than the manufacturer's standard embedment (expansion or mechanical anchors) or to provide a minimum allowable bond strength equal to the allowable yield capacity of the rod according to the manufacturer (adhesive anchors).
- c. The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long term temperature of 110 degrees F, and maximum short term temperature of 140 degrees F. In no case shall the embedment depth be less than the minimum or more than the maximum stated in the manufacturer's literature.

C. Anchors:

1. Mechanical Anchors:

- a. Wedge Anchors: Wedge anchors shall be "Kwik Bolt TZ" by Hilti, Inc., "TruBolt +" by ITW Redhead, "Strong-Bolt 2" by Simpson Strong-Tie Co. or "Power-Stud+SD1" or "Power-Stud+ SD-2" by DeWalt.
- b. Screw Anchors: Screw anchors shall be "Kwik HUS-EZ" and "KWIK HUS-EZ-I" by Hilti, Inc., "Titen HD" by Simpson Strong-Tie Co., or "Screw-Bolt+" by DeWalt. Bits specifically provided by manufacturer of chosen system shall be used for installation of anchors.
- c. Sleeve Anchors: Sleeve anchors shall be "HSL-3 Heavy Duty Sleeve Anchor" by Hilti, Inc. or "Power-Bolt +" by DeWalt.
- d. Shallow Embedment Internally Threaded Insert (3/4" max embedment): "Mini-Undercut +Anchor" by DeWalt, "HSC-A" by Hilti, Inc. or approved equal.
- e. Mechanical anchor systems shall comply with ACI 355.2 or alternatively the latest revision of AC 193, and shall have a valid evaluation report in accordance with the applicable building code.

2. Adhesive Anchors:

- a. Adhesive anchors shall be “Epcon C6+ Adhesive Anchoring System” by ITW Redhead, “HIT HY-200 Adhesive Anchoring System” by Hilti, Inc., “SET-3G Epoxy Adhesive Anchors” by Simpson Strong-Tie Co., or “Pure 110+ Epoxy Adhesive Anchor System” by DeWalt.
- b. Adhesive anchor systems shall be IBC compliant and capable of resisting short term wind and seismic loads (Seismic Design Categories A through F) as well as long term and short term sustained static loads in both cracked and uncracked concrete in all Seismic Design Categories. Adhesive anchor systems shall comply with ACI 355.4 or alternatively the latest revision of AC308, and shall have a valid evaluation report in accordance with the applicable building code. **No or equal products will be considered unless prequalified and approved by the Engineer and Owner.**

D. Concrete Anchor Materials:

1. Concrete anchors used to anchor structural steel shall be a threaded steel rod per manufacturer’s recommendations for proposed adhesive system, but shall not have a yield strength (fy) less than 58 ksi nor an ultimate strength (fu) less than 72.5 ksi, unless noted otherwise. Where steel to be anchored is galvanized, concrete anchors shall also be galvanized unless otherwise indicated on the Drawings.
2. Concrete anchors used to anchor aluminum, FRP, or stainless steel shall be Type 304 stainless steel unless noted otherwise. All underwater concrete anchors shall be Type 316 stainless steel.
3. Nuts, washers, and other hardware shall be of a material to match the anchors.

## 2.05 MASONRY ANCHORS

- A. Anchors for fastening to solid or grout-filled masonry shall be adhesive anchors as specified above for concrete anchors.
- B. Anchors for fastening to hollow masonry or brick shall be adhesive anchors consisting of threaded rods or bolts anchored with an adhesive system dispensed into a screen tube inserted into the masonry. The adhesive system shall use a two-component adhesive mix and shall inject into the screen tube with a static mixing nozzle. Thoroughly clean drill holes of all debris and drill dust prior to installation of adhesive and anchor. Contractor shall follow manufacturer’s installation instructions. The adhesive system shall be “HIT HY-70 System” as manufactured by Hilti, Inc., or “AC100+ Acrylic Adhesive” by DeWalt, “SET-XP” as manufactured by Simpson Strong-Tie Co.
- C. Masonry anchors used to anchor steel shall be a threaded steel rod per manufacturer’s recommendations for proposed adhesive system, but shall not have a yield strength (fy) less than 58 ksi nor an ultimate strength (fu) less than 72.5 ksi, unless noted otherwise. Where steel to be anchored is galvanized, masonry anchors shall also be galvanized.



- D. Masonry anchors used to anchor aluminum, FRP, or stainless steel shall be Type 304 stainless steel unless noted otherwise. All underwater anchors shall be Type 316 stainless steel.
- E. Although all manufacturers listed are permitted, the masonry anchor design is based on "SET-XP by Simpson Strong-Tie ER 265 Revised 1-31-2017. If the contractor submits one of the other concrete adhesive anchors listed, the Engineer shall evaluate the proposed product and the Contractor shall provide the conditions stipulated by the Engineer specific to the approved adhesive anchor.

## **2.06 WELDS**

- A. Electrodes for welding structural steel and all ferrous steel shall comply with AWS Code, using E70 series electrodes for shielded metal arc welding (SMAW), or F7 series electrodes for submerged arc welding (SAW).
- B. Electrodes for welding aluminum shall comply with the Aluminum Association Specifications and AWS D1.2.
- C. Electrodes for welding stainless steel and other metals shall comply with AWS D1.6.

## **2.07 WELDED STUD CONNECTORS**

- A. Welded stud connectors shall conform to the requirements of AWS D1.1 Type C.

## **2.08 EYEBOLTS**

- A. Eyebolts shall conform to ASTM A489 unless noted otherwise.

## **2.09 HASTELLOY FASTENERS**

- A. Hastelloy fasteners and nuts shall be constructed of Hastelloy C-276.

## **2.10 ANTISEIZE LUBRICANT**

- A. Antiseize lubricant shall be C5-A Anti-Seize by Loctite Corporation, Molykote P-37 Anti-Seize Paste by Dow Corning, 3M Anti-Seize by 3M, or equal.

# **PART 3 – EXECUTION**

## **3.01 MEASUREMENTS**

- A. The Contractor shall verify all dimensions and review the Drawings and shall report any discrepancies to the Engineer for clarification prior to starting fabrication.

## **3.02 ANCHOR INSTALLATION**

A. Anchor Rods, Concrete Anchors, and Masonry Anchors

1. Anchor rods shall be installed in accordance with AISC "Code of Standard Practice" by setting in concrete while it is being placed and positioned by means of a rigidly held template. Overhead adhesive anchors, and base plates or elements they are anchoring, shall be shored as required and securely held in place during anchor setting to prevent movement during anchor installation. Movement of anchors during curing is prohibited.
2. The Contractor shall verify that all concrete and masonry anchors have been installed in accordance with the manufacturer's recommendations and that the capacity of the installed anchor meets or exceeds the specified safe holding capacity.
3. Concrete anchors shall not be used in place of anchor rods without Engineer's approval.
4. All stainless steel threads shall be coated with antiseize lubricant.

B. High Strength Bolts

1. All bolted connections for structural steel shall use high strength bolts. High strength bolts shall be installed in accordance with AISC 348 "The 2009 RCSC Specification for Structural Joints". All bolted joints shall be Type N, snug-tight, bearing connections in accordance with AISC Specifications unless noted otherwise on the Drawings.

C. Concrete Anchors

1. Concrete at time of anchor installation shall be a minimum age of 21 days, have a minimum compressive strength of 2500 psi, and shall be at least 50 degrees F.
2. Concrete Anchor Testing:
  - a. At all locations, at least 10 percent of all concrete anchors installed shall be proof tested to the value indicated on the Drawings, with a minimum of one tested anchor per anchor group. If no test value is indicated on the Drawings, the Contractor shall notify the Engineer to allow verification of whether anchor load proof testing is required.
  - b. Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested, load test values and proposed anchor testing procedure (including a diagram of the testing equipment proposed for use) to the Engineer for review prior to conducting any testing. Proof testing of anchors shall be in accordance with ASTM E488 for the static tension test. If additional tests are required, inclusion of these tests shall be as stipulated on Contract Drawings.

- c. Where Contract Documents indicate anchorage design to be the Contractor's responsibility, the Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested and load test values, sealed by a Professional Engineer currently registered in the State of Georgia. The Contractor's Engineer shall also submit documentation indicating the Contractor's proof testing procedures have been reviewed and the proposed procedures are acceptable. Proof testing procedures shall be in accordance with ASTM E488.
  - d. Concrete Anchors shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the anchor after loading shall be considered a failure. Anchors exhibiting damage shall be removed and replaced. If more than 5 percent of tested anchors fail, then 100 percent of anchors shall be proof tested.
  - e. Proof testing of concrete anchors shall be performed by an independent testing laboratory hired directly by the Contractor and approved by the Engineer. The Contractor shall be responsible for costs of all proof testing, including additional testing required due to previously failed tests.
- 3. All concrete anchors shall be installed in strict conformance with the manufacturer's printed installation instructions. A representative of the manufacturer shall be on site when required by the Engineer.
  - 4. All holes shall be drilled in accordance with the manufacturer's instructions except that cored holes shall not be allowed unless specifically approved by the Engineer. If cored holes are allowed by the manufacturer and approved by the Engineer, cored holes shall be roughened in accordance with manufacturer requirements. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with the manufacturer's instructions prior to installation of adhesive and threaded rod unless otherwise recommended by the manufacturer. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer. . Injection of adhesive into the hole shall be performed to minimize the formation of air pockets in accordance with the manufacturer's instructions. Wipe rod free from oil that may be present from shipping or handling.
  - 5. All adhesive anchor installations in the horizontal to vertically overhead orientation shall be conducted by a certified Adhesive Anchor Installer as certified by ACI/CSRI per ACI 318-14 17.8.2.2. Current AAI Certificate must be submitted to the Engineer of Record prior to commencement of any adhesive anchor installations.

#### D. Other Bolts

1. All dissimilar metal shall be connected with appropriate fasteners and shall be insulated with a dielectric or approved equal.
2. All stainless steel bolts shall be coated with antiseize lubricant.

### **3.03 WELDING**

- A. All welding shall comply with AWS Code for procedures, appearance, quality of welds, qualifications of welders and methods used in correcting welded work.
- B. Welded stud connectors shall be installed in accordance with AWS D1.1.

### **3.04 INSPECTION**

- A. High strength bolting will be visually inspected in accordance with AISC 348 "The 2009 RCSC Specification for Structural Joints". Rejected bolts shall be either replaced or retightened as required.
- B. Field welds will be visually inspected in accordance with AWS Codes. Inadequate welds shall be corrected or redone as required in accordance with AWS Codes.
- C. Post-installed concrete anchors shall be inspected as required by ACI 318.

### **3.05 CUTTING OF EMBEDDED REBAR**

- A. The Contractor shall not cut embedded rebar cast into structural concrete during installation of post-installed fasteners without prior approval of the Engineer.

**END OF SECTION**

**SECTION 05 10 00**  
**METAL MATERIALS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Metal materials not otherwise specified shall conform to the requirements of this Section.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Materials for fasteners are included in Section 05 05 23 – Metal Fastening.
- B. Requirements for specific products made from the materials specified herein are included in other sections of the Specifications. See the section for the specific item in question.

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. ASTM A36 – Standard Specification for Structural Steel
- B. ASTM A47 – Standard Specification for Malleable Iron Castings
- C. ASTM A48 – Standard Specification for Gray Iron Castings
- D. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- E. ASTM A167 – Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- F. ASTM A276 – Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
- G. ASTM A307 – Standard Specification for Carbon Steel Externally Threaded Standard Fasteners
- H. ASTM A446 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) quality
- I. ASTM A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- J. ASTM A501 – Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

- K. ASTM A529 – Standard Specification for Structural Steel with 42 000 psi (290 Mpa) Minimum Yield Point (1/2 in. (12.7 mm) Maximum Thickness)
- L. ASTM A536 – Standard Specification for Ductile Iron Castings
- M. ASTM A570 – Standard Specification for Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
- N. ASTM A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- O. ASTM A992 – Standard Specification for Structural Steel Shapes
- P. ASTM A666 – Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar for Structural Applications
- Q. ASTM A1085 – Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)
- R. ASTM B26 – Standard Specification for Aluminum-Alloy Sand Castings
- S. ASTM B85 – Standard Specification for Aluminum-Alloy Die Castings
- T. ASTM B108 – Standard Specification for Aluminum-Alloy Permanent Mold Castings
- U. ASTM B138 – Standard Specification for Manganese Bronze Rod, Bar, and Shapes
- V. ASTM B209 – Standard Specification for Aluminum-Alloy Sheet and Plate
- W. ASTM B221 – Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes
- X. ASTM B308 – Standard Specification for Aluminum-Alloy Standard Structural Shapes, Rolled or Extruded
- Y. ASTM B574 – Standard Specification for Nickel-Molybdenum-Chromium Alloy Rod
- Z. ASTM F468 - Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use
- AA. ASTM F593 – Standard Specification for Stainless Steel Fasteners

#### **1.04 SUBMITTALS**

- A. Material certifications shall be submitted along with any shop drawings for metal products and fabrications required by other sections of the Specifications.

#### **1.05 QUALITY ASSURANCE**

- A. Owner may engage the services of a testing agency to test any metal materials for conformance with the material requirements herein. If the material is found to be in conformance with Specifications the cost of testing will be borne by the Owner. If the material does not conform to the Specifications, the cost of testing shall be paid by the Contractor and all materials not in conformance as determined by the Engineer shall be replaced by the Contractor at no additional cost to the Owner. In lieu of replacing materials, the Contractor may request further testing to determine conformance, but any such testing shall be paid for by the Contractor regardless of outcome of such testing.

**PART 2 – PRODUCTS**

**2.01 CARBON AND LOW ALLOY STEEL**

- A. Material types and ASTM designations shall be as listed below:

Steel W Shapes	A992
Steel HP Shapes	A572 Grade 50
Steel M, S, C, and MC shapes and Angles, Bars, and Plates	A36
Rods	F 1554 Grade 36
Pipe - Structural Use	A53 Grade B
Hollow Structural Sections	A500 Grade C or A1085
Cold-Formed Steel Framing	A 653

**2.02 STAINLESS STEEL**

- A. All stainless steel fabrications exposed to underwater service shall be Type 316. All other stainless steel fabrications shall be Type 304, unless noted otherwise.
- B. Material types and ASTM designations are listed below:

Plates and Sheets	ASTM A167 or A666 Grade A
Structural Shapes	ASTM A276
Fasteners (Bolts, etc.)	ASTM F593

**2.03 ALUMINUM**

- A. All aluminum shall be alloy 6061-T6, unless otherwise noted or specified herein.
- B. Material types and ASTM designations are listed below:

Structural Shapes	ASTM B308
Castings	ASTM B26, B85, or B108
Extruded Bars	ASTM B221 - Alloy 6061
Extruded Rods, Shapes and Tubes	ASTM B221 - Alloy 6063
Plates	ASTM B209 - Alloy 6061
Sheets	ASTM B221 - Alloy 3003

- C. All aluminum structural members shall conform to the requirements of Section 05 14 00 – Structural Aluminum.
- D. All aluminum shall be provided with mill finish unless otherwise noted.
- E. Where bolted connections are indicated, aluminum shall be fastened with stainless steel bolts.

## 2.04 CAST IRON

- A. Material types and ASTM designations are listed below:

Gray	ASTM A48 Class 30B
Malleable	ASTM A47
Ductile	ASTM A536 Grade 60-40-18

## 2.05 BRONZE

- A. Material types and ASTM designations are listed below:

Rods, Bars and Sheets	ASTM B138 - Alloy B Soft
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## 2.06 HASTELLOY

- A. All Hastelloy shall be Alloy C-276.

## 2.07 DISSIMILAR METALS

- A. Dielectric isolation shall be installed wherever dissimilar metals are connected according to the following table.



	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			•	•	•	•	•	•	•
Galvanized Steel			•	•	•	•	•	•	•
Aluminum	•	•		•	•	•	•	•	•
Cast Iron	•	•	•				•	•	•
Ductile Iron	•	•	•				•	•	•
Mild Steel/ Carbon Steel	•	•	•				•	•	•
Copper	•	•	•	•	•	•			•
Brass	•	•	•	•	•	•			•
Stainless Steel	•	•	•	•	•	•	•	•	
1. "•" signifies dielectric isolation is required between the two materials noted. 2. Consult Engineer for items not listed in table.									

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

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**SECTION 05 12 00**  
**STRUCTURAL STEEL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all equipment, labor, materials, and services required to provide all structural steel work in accordance with the Contract Documents. The term "structural steel" shall include items as defined in the AISC "Code of Standard Practice".

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 05 23 – Metal Fastening

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents.
  - 1. Georgia State Minimum Standard Building Code
  - 2. AISC – "Code of Standard Practice"
  - 3. AISC – "Specification for Structural Steel Buildings"
  - 4. AISC 348 – "The 2009 RCSC Specification for Structural Joints"
  - 5. AWS – "Structural Welding Code"

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Certified Mill Test Reports
  - 2. Affidavit of Compliance with grade specified
  - 3. Shop Drawings which include the following:
    - a. Layout drawings indicating all structural shapes, sizes, and dimensions.
    - b. Beam and column schedules.

- c. Detailed drawings indicating jointing, anchoring and connection details and vent and drain holes where required.

## **1.05 QUALITY ASSURANCE**

- A. Shop inspection may be required by the Owner at his own expense. The Contractor shall give ample notice to the Engineer prior to the beginning of any fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the work. Inspectors shall have the authority to reject any materials or work which do not meet the requirements of these Specifications. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship under this Specification.
- B. The erector shall be a qualified installer who participates in the AISC Certification program and is designated an AISC Certified Erector, Category ACSE.
- C. The fabricator shall be a qualified fabricator who participates in the AISC Certification program and is designated an AISC Certified Plant, Category STD.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

- A. Structural Steel
  - 1. Structural steel for W shapes shall conform to ASTM A992 unless otherwise indicated.
  - 2. Structural steel for HP shapes shall conform to ASTM A572 Grade 50 unless otherwise indicated.
  - 3. Structural steel for S, M, C, and MC shapes and angles and plates shall conform to ASTM A36 unless otherwise indicated.
  - 4. Steel pipe shall be ASTM A53, Grade B.
  - 5. HSS shall be ASTM A500, Grade C or ASTM A1085. All members shall be furnished full length without splices unless otherwise noted or accepted by the Engineer.
  - 6. All unidentified steel will be rejected and shall be removed from the site and replaced by the Contractor, all at the expense of the Contractor.
  - 7. Fasteners for structural steel shall be in accordance with Section 05 05 23 – Metal Fastening.

B. Welds

1. Electrodes for welding shall be in accordance with Section 05 05 23 – Metal Fastening.

## **PART 3 – EXECUTION**

### **3.01 MEASUREMENT**

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of work. The Contractor shall review the Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

### **3.02 FABRICATION**

- A. Fabrication shall be in accordance with the AISC "Specification for Structural Steel Buildings and AISC "Code of Standard Practice". Fabrication shall begin only after Shop Drawing approval.
- B. Except where otherwise noted on the Drawings or in this Specification, all shop connections shall be welded.
- C. All holes in structural steel members required for anchors, anchor rods, bolts, sag rods, vent and drain holes or other members or for attachment of other work shall be provided by the fabricator and detailed on the Shop Drawings.
- D. All materials shall be properly worked and match-marked for field assembly.
- E. Where galvanizing of structural steel is required, it shall be done in accordance with Section 05 05 13 – Galvanizing.

### **3.03 DELIVERY, STORAGE AND HANDLING**

- A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.
- B. Structural steel members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. The Contractor shall repair or replace damaged materials or structures as directed.

### **3.04 ERECTION**

- A. The erection of all structural steel shall conform to the applicable requirements of the AISC "Specification for Structural Steel Buildings" and AISC "Code of Standard

Practice". All temporary bracing, guys and bolts as may be necessary to ensure the safety of the structure until the permanent connections have been made shall be provided by the Contractor.

- B. Structural members shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before permanently fastened.
- C. No cutting of structural steel members in the field will be allowed except by the written approval of the Engineer.
- D. Bearing surfaces and other surfaces which will be in permanent contact shall be cleaned before assembly.
- E. Field welding shall not be permitted unless specifically indicated in the Drawings or approved in writing by the Engineer. All field welding shall comply with Section 05 05 23 – Metal Fastening.
- F. All bolted connections shall use high strength bolts in accordance with Section 05 05 23 – Metal Fastening. High strength bolts shall be installed in accordance with AISC 348 “The 2009 RCSC Specification for Structural Joints”. Bolts specified or noted on the Drawings to be a tension or slip critical “SC” type connection shall be fully pretensioned with proper preparation of the faying surfaces. All other bolts shall be snug tightened unless otherwise noted on the Drawings.
- G. All field connections shall be accurately fitted up before being bolted. Drifting shall be only such as will bring the parts into position and shall not be sufficient to enlarge the holes or to distort the metal. All unfair holes shall be drilled or reamed.
- H. Misfits at Bolted Connections
  - 1. Where misfits in erection bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.
  - 2. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins. The Contractor shall notify the Engineer immediately and shall submit a proposed method of remedy for review by the Engineer.
  - 3. Where misalignment between anchor rods and rod holes in steel members are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misalignment for review by the Engineer.
- I. Grouting of Base Plates and Bearing Plates

1. The bottom surface of the plates shall be cleaned of all foreign materials, and concrete or masonry bearing surface shall be cleaned of all foreign materials and roughened to improve bonding.
  2. Accurately set all base and bearing plates to designated levels with steel wedges or leveling plates.
  3. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure. Non-shrink grout shall conform to Section 03 60 00 – Grout.
  4. Anchor rods shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its specified strength.
- J. Where finishing is required, assembly shall be completed including bolting and welding of units before start of finishing operations.

### **3.05 PAINTING**

- A. Painting shall be performed according to Section 09 90 00 – Painting and the following additional requirements.
1. Concrete Encased Steel: Steel members which will be encased in concrete shall be cleaned but not painted prior to encasement.
  2. Contact Surfaces: Contact surfaces such as at field connections, shall be cleaned and primed but not painted.
  3. Finished Surfaces: Machine finished surfaces shall be protected against corrosion by a rust-inhibiting coating which is easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.
  4. Surfaces Adjacent to Field Welds: Surfaces within 2 inches of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

**END OF SECTION**

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**SECTION 05 13 00**  
**STAINLESS STEEL**

**PART 1 – GENERAL**

**1.01 SECTION INCLUDES**

- A. The Contractor shall furnish, install and erect the stainless steel work as shown on the Contract Drawings and specified herein.
- B. Stainless steel work shall be furnished complete with all accessories, mountings and appurtenances of the type of stainless steel and finish as specified or required for a satisfactory installation.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 33 00 – Submittal Procedures
- B. Section 05 10 00 – Metal Materials
- C. Section 05 05 23 – Metal Fastening
- D. Section 05 50 00 – Metal Fabrications

**1.03 REFERENCES**

- A. ASTM A193 – Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
- B. ASTM A194 – Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
- C. ASTM A262 – Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel
- D. ASTM A276 – Stainless and Heat-Resisting Steel Bars and Shapes
- E. ASTM A314 – Stainless and Heat-Resisting Steel Billets and Bars for Forging
- F. ASTM A380 – Practice for Cleaning and Descaling Stainless Steel Parts, Equipment and Systems
- G. ASTM A473 – Stainless and Heat-Resisting Steel Forgings
- H. ASTM A666 – Austenitic Stainless Steel, Sheet, Strip, Plate and Flat Bar
- I. ASTM A774 – Stainless Steel Pipe Fittings

- J. ASTM A778 – Stainless Steel Pipe
- K. ASTM F593 – Stainless Steel Bolts, Hex Cap Screws and Studs
- L. ASTM F594 – Stainless Steel Nuts
- M. ANSI/ASME B1.1 – Unified Inch Screw Thread (UN and UNR Thread Form)

#### **1.04 TESTS**

- A. All stainless steel materials including stainless test welds, shall be checked for compliance with tests for susceptibility to intergranular attack. Such tests shall be Practices A, B and E of ASTM A262. Detailed procedures for the tests shall be submitted to the Engineer for approval prior to start of work. Practice A shall be used only for acceptance of materials but not for rejection of materials, and shall be used for screening material intended for testing in Practice B and Practice E. The maximum acceptable corrosion rate under Practice B shall be 0.004 inch per month, rounded off to the third decimal place. If the certified mill report indicates that such test has been satisfactory performed, the fabricator may not be required to repeat the test. Material passing Practice E shall be acceptable.
- B. Sample selection for the susceptibility to intergranular attack tests shall be as follows:
  - 1. One (1) sample per heat treatment lot for plates and forgings;
  - 2. One (1) sample per each Welding Procedure Qualification regardless of the joint design;
  - 3. If tests indicate a reduction in corrosion resistance, welding procedure shall be adjusted or heat treatment determined as needed to restore required corrosion resistance.
  - 4. The samples so chosen shall have received all the post-weld heat treatments identical to the finished part.

#### **1.05 SUBMITTALS**

- A. The Contractor shall prepare and submit for approval shop drawings for all stainless steel fabrication in accordance with Section 01 33 00 – Submittal Procedures.
- B. Submittals shall include, but not be limited to, the following:
  - 1. Certified test reports for susceptibility to intergranular attack.
  - 2. Affidavit of compliance with type of stainless steel shown on the Contract Drawings or specified herein.
  - 3. Certified weld inspection reports.

4. Cleaning and handling of stainless steel in accordance with Paragraph 3.04, Cleaning and Handling.
- C. Samples of finish, on each type of stainless steel to be furnished, shall be submitted to the Engineer upon request.

#### **1.06 QUALITY ASSURANCE**

- A. Shop inspections may be made by the Engineer. The Contractor shall give ample notice to the Engineer prior to the beginning of any stainless steel fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the works.
- B. Inspectors shall have the authority to reject any materials or work which does not meet the requirements of the Contract Drawings or the Specifications.
- C. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship.

#### **1.07 HANDLING, STORAGE AND DELIVERY**

- A. Mechanical damage (e.g., scratches and gouges) to the stainless steel material shall not be permitted and is cause for rejection. Care shall be taken in the material handling since such mechanical damage will result in the passive oxide film being "punctured" leading to a possible lower resistance to the initiation of corrosion than the surrounding chemically-passivated surface.
- B. Stainless steel plates and sheets shall be stored vertically in racks and not be dragged out of the racks or over one another. Racks shall be protected to prevent iron contamination.
- C. Heavy stainless steel plates shall be carefully separated and chocked with wooden blocks so that the forks of a fork-lift could be inserted between plates without mechanically damaging the surface.
- D. Stainless steel plates and sheets laid out for use shall be off the floor and be divided by wooden planks to prevent surface damage and to facilitate subsequent handling.
- E. Plate clamps, if used, shall be used with care as the serrated faces can dig in, indent and gouge the surface.
- F. Stainless steel fabrications shall be loaded in such a manner that they may be transported and unloaded without being overstressed, deformed or otherwise damaged.
- G. Stainless steel fabrications and packaged materials shall be protected from corrosion and deterioration and shall be stored in a dry area. Materials stored outdoors shall be

supported above ground surfaces on wood runners and protected with approved effective and durable covers.

- H. Stainless steel fabrications shall not be placed in or on a structure in a manner that might cause distortion or damage to the fabrication. The Contractor shall repair or replace damaged stainless steel fabrications or materials as directed by the Engineer.

## **1.08 FIELD MEASUREMENTS**

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.
- B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS AND FINISHES**

- A. Stainless steel shall be Type 304 unless it is used for underwater service. Stainless steel for underwater service shall be Type 316. Minimum mechanical finish shall be No. 4 as stated in Table 2 unless otherwise noted on the Contract Drawings.
- B. The basic mill forms (sheet, strip, plate and bar) are classified by size as shown on Table 1. Tables 2, 3 and 4 identify finishes and conditions in which sheet, bar and plate are available.
- C. Tables 2, 3 and 4 show numbered finishes and conditions for sheet, bar and plate. While there are no specific designations for polished finishes on bar or plate, the sheet finish designations are used to describe the desired effect. This also applies to finishes on ornamental tubing.
- D. There are three standard finishes for strip, which are broadly described by the finishing operations employed:
  - 1. No. 1 Strip Finish
    - a. No. 1 strip finish is approximately the same as No. 2D Sheet Finish. It varies in appearance from dull gray matte to a fairly reflective surface, depending largely on alloy composition and amount of cold reduction.
  - 2. No. 2 Strip Finish is approximately the same as a No. 2B sheet finish. It is smoother, more reflective than No. 1, and likewise varies with alloy composition.
  - 3. Bright annealed finish is a highly reflective finish that is retained by final annealing in a controlled atmosphere furnace.

**Table 1: Classification of Stainless Steel Product Form**

Item	Description	Dimensions		
		Thickness	Width	Diameter or Size
Sheet	Coils and cut length:			
	Mill finishes Nos. 1, 2D and 2B	under 3/16"	24" and over all widths	-
	Polished finishes Nos. 3, 4, 6, 7 & 8			
Strip	Cold finished, coils or cut lengths:			
	Polished finishes Nos. 3, 4, 6,7 & 8	under 3/16"	under 24" all widths	-
Plate	Flat rolled or forged	3/16" and over	over 10"	-
Bar	Hot finished rounds, squares, octagons and hexagons	-	-	1/4" and over
	Hot finished flats	1/8" to 8" incl.	1/4" to 10" incl.	-
	Cold finished rounds, squares, octagons and hexagons	-	-	over 1/8"
	Cold finished flats	1/8" to 4-1/2"	3/8" to 4-1/2"	-
Wire	Cold finishes only: (in coil)			
	Round, square, octagon, hexagon and flat wire	under 3/16"	under 3/8"	-
Pipe & Tubing	Several different classifications, with differing specifications, are available.			
Extrusion	Not considered "standard" shapes. Currently limited in size to approximately 6-1/2" diameter or structurals.			

**Table 2: Standard Mechanical Sheet Finishes**

Unpolished or Rolled Finishes		Polished Finishes	
<b>No. 1</b>	A rough dull surface which results from hot rolling to the specified thickness followed by annealing and descaling.	<b>No. 3</b>	An intermediate polish surface obtained by finishing with a 100 grit abrasive. Generally used where a semi-finished polished surface is required. A No. 3 finish usually receives additional polishing during fabrication
<b>No. 2D</b>	A dull finish which results from cold rolling followed by annealing and descaling, and may perhaps get a final light roll pass through unpolished rolls. A 2D finish is used where appearance is of no concern.	<b>No. 4</b>	A polished surface obtained by finishing with a 120-150 mesh abrasive, following initial grinding with coarser abrasives. This is a general purpose bright finish with a visible "grain" which prevents mirror reflection.
<b>No. 2B</b>	A bright cold-rolled finish resulting in the same manner as No. 2D finish, except that the annealed and descaled sheet receives a final light roll pass through polished rolls. This is the general purpose cold-rolled finish that can be used as is, or as a preliminary step to polishing.	<b>No. 6</b>	A dull satin finish having lower reflectivity than No. 4 finish. It is produced by Tampico brushing the No. 4 finish in a medium of abrasive and oil. It is used for architectural applications and ornamentation where a high luster is undesirable, and to contrast with brighter finishes.
		<b>No. 7</b>	A high reflective finish that is obtained by buffing finely ground surfaces but not to the extent of completely removing the "grit" lines. It is used chiefly for architectural and ornamental purposes.
		<b>No. 8</b>	The most reflective surface, which is obtained by polishing with successively finer abrasives and buffing extensively until all grit lines from preliminary grinding operations are removed. It is used for applications such as mirrors and reflectors.

**Table 3: Conditions and Finishes for Bar**

Conditions	Surface Finishes <sup>1</sup>
Hot worked only	(a) Scale not removed (excluding spot conditioning) (b) Rough turned <sup>2</sup> (c) Pickled or blast cleaned and pickled.
Annealed or otherwise heat treated	(a) Scale not removed (excluding spot conditioning) (b) Rough turned (c) Pickled or blast cleaned and pickled (d) Cold drawn or cold rolled (e) Centerless ground (f) Polished
Annealed and cold worked to high tensile strength <sup>3</sup>	(a) Cold drawn or cold rolled (b) Centerless ground (c) Polished

**Table 4: Conditions and Finishes for Plate**

Condition and Finish	Description and Remarks
Hot rolled	Scale not removed. Not heat treated. Plates not recommended for final use in this condition. <sup>4</sup>
Hot rolled, annealed or heat treated	Scale not removed. Use of plates in this condition is generally confined to heat resisting applications. Scale impairs corrosion resistance. <sup>1</sup>
Hot rolled, annealed or heat treated, blast cleaned or pickled	Condition and finish commonly preferred for corrosion resisting and most heat resisting applications.
Hot rolled, annealed, descaled and temper passed	Smoother finish for specialized applications.
Hot rolled, annealed, descaled cold rolled, annealed, descaled, optionally temper passed	Smooth finish with greater freedom from surface imperfection than the above.
Hot rolled, annealed or heat treated, surface cleaned and polished	Polished finishes refer to Table 2.

<sup>1</sup> Surface finishes (b), (e) and (f) are applicable to round bars only.

<sup>2</sup> Bars of the 4xx series stainless steels which are highly hardenable, such as Types 414, 420, 420F, 431, 440A, 440B and 440C, are annealed before rough turning. Other hardenable grades, such as Types 403, 410, 416 and 416Se, may also require annealing depending on their composition and size.

<sup>3</sup> Produced in Types 302, 303Se, 304 and 316.

<sup>4</sup> Surface inspection is not practicable on plates which have not been pickled or otherwise descaled.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION**

- A. Holes for bolts and screws shall be drilled. Fastenings shall be concealed where practicable. Joints exposed to the weather shall be formed to exclude water.
- B. As far as practicable, all fabricated units shall be fitted and assembled in the shop, with all cuts and bends made to precision measurements in accordance with details shown on approved shop drawings.
- C. Work shall be fabricated so that it is installed in a manner that will provide for expansion and contraction, prevent the shearing of bolts, screws and other fastenings, ensure rigidity, and provide close fitting of sections.
- D. All finished and/or machined faces shall be true to line and level. Stainless steel sections shall be well formed to shape and size with sharp lines and angles; curved work shall be sprung evenly to curves.
- E. All work shall be fitted together at the shop as far as possible, and delivered complete and ready for erection. Proper care shall be exercised in handling all work so as not to injure the finished surfaces.

### **3.02 WELDING**

- A. Welding shall be done in a manner that will prevent buckling and in accordance with Section 05 05 23 – Metal Fastening, and as modified hereinafter.
- B. All welds exposed in the work shall be ground smooth and finished to match the finish of the adjacent stainless steel surfaces.
- C. Select weld rods that provide weld filler metal having corrosion resistant properties as nearly identical or better than the base metal to insure preservation of the corrosion-resistant properties. Provide heat treatment at welds where testing of weld procedure indicates it is required to restore the corrosion resistance.
- D. Thermal conductivity of stainless steel is about half that of other steels; and the following methods may be used to accommodate this situation:
  - 1. Use lower weld current setting.
  - 2. Use skip-weld techniques to minimize heat concentration.
  - 3. Use back-up chill bars or other cooling techniques to dissipate heat.
- E. Edges of the stainless steel to be welded shall be cleaned of contaminants.

### **3.03 FASTENERS**



- A. Stainless steel fasteners shall be used for joining stainless steel work.
- B. Stainless steel fasteners shall be made of alloys that are equal to or more corrosion resistant than the materials they join.

### **3.04 CLEANING AND HANDLING**

- A. All stainless steel surfaces shall be precleaned, descaled, passivated and inspected before, during and after fabrication in accordance with the applicable sections of ASTM A380 and as detailed in the procedures to be submitted to the Engineer for approval prior to start of work. Degreasing and passivation of stainless steel articles shall be conducted as the last step after fabrication.
- B. Measures to protect cleaned surfaces shall be taken as soon as final cleaning is completed and shall be maintained during all subsequent handling, storage and shipping.
  - 1. The Contractor shall submit for approval specific procedures listing all the steps to be followed in detecting contamination and in descaling, cleaning, passivation and protecting of all stainless steel.
  - 2. Area showing clear indications of contamination shall be recleaned, repassivated and reinspected.
- C. At approved stages in the shop operations, contaminants such as scale, embedded iron, rust, dirt, oil, grease and any other foreign matter shall be removed from the metal, as directed or approved by the Engineer. The adequacy of these operations shall be checked by the Engineer. Operations in the shop shall be conducted so as to avoid contamination of the stainless steel and to keep the metal surfaces free from dirt and foreign matter.
- D. In order to prevent incipient corrosion during fabrication, special efforts shall be made at all times to keep all stainless steel surfaces from coming in contact with other metals.
  - 1. Stainless steel and stainless steel welds shall be cleaned with clean sand free of iron, stainless steel wool, stainless steel brushes, or other approved means and shall be protected at all times from contamination by any materials, including carbon steel, that shall impair its resistance to corrosion.
  - 2. Approved methods of cutting, grinding and handling shall be used to prevent contamination. If air-arc, or carbon-arc cutting is used, additional metal shall be removed by approved mechanical means so as to provide clean, weldable edges. All grinding of stainless steel shall be performed with aluminum oxide or silicon carbide grinding wheels bonded with resin or rubber. Grinding wheels used on carbon steel shall not be used on stainless steel.

3. Sand, grinding wheels, brushes and other materials used for cleaning stainless steel shall be checked periodically by the Engineer for contaminants. Cleaning aids found to contain contaminants shall not be used on the work.

### **3.05 INSTALLATION**

- A. All stainless steel fabrications shall be erected square, plumb and true, accurately fitted, adequately anchored in place, set at proper elevations and positions.
- B. All inserts, anchor rods and all other miscellaneous work specified in the Detailed Specifications or shown on the Contract Drawings or required for the proper completion of the work, which are embedded in concrete, shall be properly set and securely held in position in the forms before the concrete is placed.
- C. All stainless steel fabrications shall be installed in conformance with details shown on the Contract Drawings or on the approved shop drawings.

**END OF SECTION**

**SECTION 05 14 00**  
**STRUCTURAL ALUMINUM**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all equipment, labor, materials, and services required to provide all structural aluminum work in accordance with the Contract Documents. The term "structural aluminum" shall include items as defined in the Aluminum Association "Specifications for Aluminum Structures".

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening
- C. Section 09 90 00 – Painting

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of the Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. Aluminum Association "Specifications for Aluminum Structures"
  - 3. AWS D1.2 – "Structural Welding Code"

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Certified Mill Test Reports
  - 2. Affidavit of Compliance with grade specified
  - 3. Shop Drawings which include the following:
    - a. Layout drawings indicating all structural shapes, sizes, and dimensions.
    - b. Beam and column schedules.

- c. Detailed drawings indicating jointing, anchoring and connection details.

## **1.05 QUALITY ASSURANCE**

- A. Shop inspection may be required by the Owner at his own expense. The Contractor shall give ample notice to the Engineer prior to the beginning of any fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the work. Inspectors shall have the authority to reject any materials or work which do not meet the requirements of these Specifications. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship under this Specification.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

- A. Structural aluminum shall comply with Section 05 10 00 – Metal Materials.
- B. Fasteners for structural aluminum shall be in accordance with Section 05 05 23 – Metal Fastening.
- C. Electrodes for welding shall be in accordance with Section 05 05 23 – Metal Fastening.

## **PART 3 – EXECUTION**

### **3.01 MEASUREMENT**

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of work. The Contractor shall review the Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

### **3.02 FABRICATION**

- A. Fabrication shall be in accordance with the Aluminum Association "Specifications for Aluminum Structures". Fabrication shall begin only after Shop Drawing approval.
- B. Except where otherwise noted on the Drawings or in this Specification, all shop connections shall be welded.
- C. All holes in structural aluminum members required for anchors, anchor rods, bolts, or other members or for attachment of other work shall be provided by the fabricator and detailed on the Shop Drawings.

- D. All materials shall be properly worked and match-marked for field assembly.

### **3.03 DELIVERY, STORAGE AND HANDLING**

- A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.
- B. Structural aluminum members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. The Contractor shall repair or replace damaged materials or structures as directed.

### **3.04 ERECTION**

- A. All temporary bracing, guys and bolts as may be necessary to ensure the safety of the structure until the permanent connections have been made shall be provided by the Contractor.
- B. Structural members shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before being permanently fastened.
- C. No cutting of structural aluminum members in the field will be allowed except by the written approval of the Engineer.
- D. Bearing surfaces and other surfaces which will be in permanent contact shall be cleaned before assembly.
- E. Field welding shall not be permitted unless specifically indicated in the Drawings or approved in writing by the Engineer. All field welding shall comply with Section 05 05 23 – Metal Fastening.
- F. All bolted connections shall comply with Section 05 05 23 – Metal Fastening.
- G. All field connections shall be accurately fitted up before being bolted. Drifting shall be only such as will bring the parts into position and shall not be sufficient to enlarge the holes or to distort the metal. All unfair holes shall be drilled or reamed.
- H. Misfits at Bolted Connections
  - 1. Where misfits in erection bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.

2. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins. The Contractor shall notify the Engineer immediately and shall submit a proposed method of remedy for review by the Engineer.
  3. Where misalignment between anchor bolts and bolt holes in aluminum members are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misalignment for review by the Engineer.
- I. Grouting of Base Plates and Bearing Plates
1. The bottom surface of the plates shall be cleaned of all foreign materials, and concrete or masonry bearing surface shall be cleaned of all foreign materials and roughened to improve bonding.
  2. Accurately set all base and bearing plates to designated levels with steel wedges or leveling plates.
  3. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure. Non-shrink grout shall conform to Section 03 60 00 – Grout.
  4. Anchor bolts shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its specified strength.
- J. Where finishing is required, assembly shall be completed including bolting and welding of units before start of finishing operations.

### **3.05 PAINTING**

- A. Painting shall be performed according to Section 09 90 00 – Painting.
- B. Aluminum surfaces in contact with concrete or dissimilar metals shall be thoroughly protected with two coats of epoxy paint with a minimum total thickness of 16 mils or other approved isolating material in accordance with the requirements of Section 09 90 00 – Painting.

**END OF SECTION**

**SECTION 05 50 00**  
**METAL FABRICATIONS**

**PART 1 – GENERAL**

**1.01 REQUIREMENT**

- A. Furnish all materials, labor, and equipment required to provide all metal fabrications not specifically included in other Sections, complete and in accordance with the requirements of the Contract Documents.
- B. Work shall include but may not be limited to guard posts, hoppers, and chutes.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening
- C. Section 05 05 13 – Galvanizing
- D. Certain specific items are included in other Sections of the Specifications. See the section for the specific item in question.

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. AISC – Specification for Structural Steel Buildings
  - 3. AISI – Specifications for the Design of Cold-Formed Steel Structural Members
  - 4. Aluminum Association Specifications for Aluminum Structures

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Complete fabrication and erection drawings of all metalwork specified herein.
  - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

## **PART 2 – PRODUCTS**

### **2.01 METAL MATERIALS**

- A. Metal materials used in metal fabrications shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

### **2.02 METAL FASTENING**

- A. All welds and fasteners used in metal fabrication shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

### **2.03 GUARD POSTS (BOLLARDS)**

- A. Guard posts shall be 6-inch diameter Schedule 40 galvanized steel pipe in accordance with ASTM A53.
- B. Guard posts shall be concrete filled and crowned, as detailed in the Drawings.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION**

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.
- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.
- G. Fabricated items shall be shop painted when specified in Section 09 90 00 – Painting.



### **3.02 INSTALLATION**

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.
- C. Metal work shall be field painted when as specified in accordance with Section 09 90 00 – Painting.

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## **SECTION 05 51 33**

### **LADDERS**

#### **PART 1 – GENERAL**

##### **1.01 REQUIREMENT**

- A. Furnish all materials, labor, and equipment required to provide all ladders in accordance with the requirements of the Contract Documents.

##### **1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening

##### **1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents.
  - 1. Georgia State Minimum Standard Building Code
  - 2. Aluminum Association Specifications for Aluminum Structures
  - 3. Occupational Safety and Health Administration (OSHA) Regulations

##### **1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Complete fabrication and erection drawings of all metalwork specified herein.
  - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

#### **PART 2 – PRODUCTS**

##### **2.01 METAL MATERIALS**

- A. Metal materials used for ladders shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

##### **2.02 METAL FASTENING**

- A. All welds and fasteners used for ladders shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

### **2.03 LADDERS**

- A. Ladders shall be furnished with all mounting brackets, baseplates, fasteners, and necessary appurtenances for a complete and rigid installation.
- B. All ladders shall be 316 SST.
- C. All ladders shall conform to dimensions indicated on the Drawings and shall comply with OSHA requirements.
- D. Side rails shall be 1-1/2 inch diameter Schedule 80 pipe, minimum.
- E. Rungs shall be serrated 3/4 inch diameter, minimum.
- F. All exposed connections shall be welded and ground smooth.
- G. Ladders shall be as manufactured by Thompson Fabricating Company, or equal.

### **2.04 LADDER SAFETY SYSTEM**

- A. All ladders with an uninterrupted length exceeding 20 ft. between landings or floors shall be installed with a ladder safety system.
- B. Ladder safety system shall comply with OSHA requirements and meet ANSI A14.3 requirements.
- C. Ladder safety system shall include all necessary components to provide a fully operational system, including one full body safety harness with a 310 lb. weight capacity for each ladder safety system.
- D. Ladder Safety Systems shall be Miller Vi-Go by Honeywell, LAD\_SAF by DBI Sala, or approved equal.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION**

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection.

- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.
- G. Fabricated items shall be shop painted when specified in accordance with Section 09 90 00 – Painting.

### **3.02 INSTALLATION**

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.
- C. Metalwork shall be field painted when specified in accordance with Section 09 90 00 – Painting.

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**SECTION 05 53 00**  
**GRATINGS, ACCESS HATCHES, AND ACCESS DOORS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all materials, labor, and equipment required to provide all gratings, floor plates, and hatches in accordance with the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 05 23 – Metal Fastening

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Minimum Standard Building Code
  - 2. Aluminum Association Specifications for Aluminum Structures
  - 3. Occupational Safety and Health Administration (OSHA) Regulations

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Complete fabrication and erection Drawings of all gratings, access hatches, and access doors specified herein.
  - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials, and Section 05 05 23 – Metal Fastening.

## **PART 2 – PRODUCTS**

### **2.01 METAL MATERIALS**

- A. Metal materials used for gratings, floor plates, and hatches shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

### **2.02 METAL FASTENING**

- A. All welds and fasteners used for gratings, floor plates, and hatches shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

### **2.03 GRATING**

- A. General - Grating, including support frames, fastenings, and all necessary appurtenances for a complete installation, shall be furnished as indicated on the Drawings.
  - 1. All exposed bearing ends of grating shall be enclosed in a perimeter band of the same dimensions and material as the main bars, including ends at all cutouts.
  - 2. Grating shall be fabricated into easily removable sections and shall be fastened at each corner and as required with fasteners provided by the grating manufacturer. No fasteners shall be permitted to project above the walking surface.
  - 3. Grating shall be designed for a loading of 150 psf unless otherwise required by the Drawings. Grating deflection shall not exceed 1/4 inch under a uniform load of 100 psf. Minimum grating depth shall be 1-1/2 inches, unless structural requirements based on clear span require more depth.
  - 4. Grating installed in cast-in-place concrete shall be provided with embedded support frames on all perimeter and bearing edges. Support frames shall include anchor straps or headed studs at a maximum of 18” on-center, a minimum of two each side. Support frames shall be fabricated from the same material as the grating.
- B. Aluminum Grating
  - 1. Aluminum grating shall be of I-bar type and shall consist of extruded bearing bars positioned and locked by crossbars. All supports, cross members, etc. shall be aluminum. Plank clips for grating holddowns or other required attachments, shall be aluminum or stainless steel. Bolts shall be stainless steel. Provide embedded aluminum support frames for cast-in-place concrete installations.
  - 2. Grating shall be “19-SI-4 I-Bar Swage Locked” by Alabama Metal Industries Corporation (AMICO), “IB” by Harsco Industrial IKG, “I-Bar 19SGI4”, by Ohio Grating Inc., or “I-Bar” by Thompson Fabricating LLC.



### C. Stainless Steel Grating

1. Stainless Steel grating shall be pressure locked or welded type with parallel bearing bars spaced not more than 1-3/16 inches on centers jointed by cross members spaced not more than 4 inches on center.
2. Grating shall be serrated. Depth of serrated grating shall not be less than 1/4 inch greater than the required standard bar grating.
3. Stainless Steel Grating shall be fabricated into easily removable sections and shall be fastened at each corner and at every 12 inches at the bearing ends. Fasteners shall be stainless steel provided by the manufacturer. No fasteners shall be permitted to project above the walking surface.
4. Grating members, fasteners, hold down clips, and other required attachments shall be Type 316 stainless steel.
5. Grating shall be manufactured by Alabama Metal Industries Corporation (AMICO), Harsco Industrial IKG, or Ohio Grating Inc.

### 2.04 ACCESS HATCHES

- A. Access hatches shall be aluminum unless noted otherwise.
- B. All access hatches shall be checker plate with an approved raised pattern, non-skid surface.
- C. Access hatches shall be designed to carry a minimum live load of 150 psf, or a concentrated load of 300 pounds at the center, whichever produces the greatest stress.
- D. Access hatches shall not exceed an allowable fiber stress of 16,000 psi. Live load deflection shall be limited to L/240 of the span, but not more than 1/4-inch.
- E. All access hatches shall be fabricated from 1/4" plate, minimum and shall be stiffened as required to maintain allowable stress and deflection requirements specified herein. Stiffeners shall consist of angles or bars welded to the bottom of the plate.
- F. Hinges, where indicated on the Drawings, shall be insulated, heavy-duty, cadmium plated bronze with stainless steel pins and fasteners.
- G. All access hatches as indicated on the Drawings shall be provided with recessed handles. Handle material shall be as shown on the Contract Drawings.
- H. Air-tight and water-tight access hatches shall be provided with a 1/8 inch thick neoprene gasket between the checkered plate and the support frame. Gasket material shall be bonded to the support frame and access hatches shall be bolted to the structural support frame with countersunk stainless steel flathead screws.

## 2.05 ACCESS DOORS

### A. General

1. Door opening sizes, number and direction of swing of door leaves, and locations shall be as shown on the Drawings. The Drawings shall indicate the clear opening dimensions.
2. All doors shall be aluminum unless otherwise noted.
3. Openings larger than 42 inches in either direction shall have double leaf doors.
4. Doors shall be designed for flush mounting and for easy opening from both inside and outside.
5. All doors shall be provided with an automatic hold-open arm with release handle.
6. Double leaf doors shall be provided with safety bars to go across the open sides of the door, when in the open position. Brackets shall be provided on the underside of the doors to hold the safety bars when not in use.
7. All hardware, including but not limited to, all parts of the latch and lifting mechanism assemblies, hold open arms and guides, brackets, hinges, springs, pins, and fasteners shall be stainless steel.
8. All doors shall be watertight with a continuous gasket. All single door applications shall include a continuous EPDM odor reduction gasket.
9. Door frames shall be extruded and equipped with a 1-1/2 inch minimum drain pipe located by the manufacturer. The drain pipe shall be provided by the Contractor and shall extend to the nearest point of discharge acceptable to the Engineer.

### B. Floor, Wet Well and Dry Pit Access Doors

1. Door leaves shall be 1/4 inch, minimum, diamond pattern plate with an approved raised pattern, non-skid surface. Plate shall be stiffened as required to maintain allowable stress and deflection requirements. Stiffeners shall consist of angles or bars welded to the bottom of plate.
2. Doors shall be designed for a 300 psf live load minimum, unless noted otherwise.
3. Doors shall be designed for flush mounting and for easy opening from both inside and outside.
4. All doors shall have an enclosed compression spring assist and open to 90 degrees.

5. Exterior doors shall be Type "J-AL" or "JD-AL", by Bilco Company, Type "W1S" or "W2S" by Halliday Products Inc., Type "TPS" or "TPD", by U.S.F. Fabrication Inc., Type "THG" or "THG-D", by Thompson Fabricating LLC.
6. Interior doors shall be Type "K" or "KD", by Bilco Company, Type "S1S" or "S2S" by Halliday Products Inc., Type "APS300" or "APD300", by U.S.F. Fabrication Inc., Type "TH" or "TH-D", by Thompson Fabricating LLC.
7. Doors rated for H-20 traffic loading shall be "JAL-HD" or "JDAL-HD" by the Bilco Company, Type "H1C" or "H2C" by Halliday Products, Inc., or Type "THS" or "THD" by U.S.F. Fabrication Inc.

C. Roof Access Doors

1. Doors shall be designed for 50 psf live load unless noted otherwise.
2. Doors for service stairs shall be Bilco Type L roof Scuttles.
3. Doors for ladder access shall be Bilco Type S or SS Roof Scuttles.

D. Fixed Ladders

1. Where the Contract Documents indicate fixed ladders are required under access doors, they shall be provided with "LadderUp, Model LU-4" by Bilco Company, "L1E Ladder Extension" by Halliday Products Inc., or "Ladder Climb-out Device" by Thompson Fabricating.
2. The safety posts shall be manufactured of the same material as the access door with telescoping tubular sections that lock automatically when fully extended.
3. Upward and downward movement shall be controlled by a stainless steel balancing mechanism.
4. Safety posts shall be assembled in strict accordance with manufacturer's recommendations.

## **2.06 FALL THROUGH PREVENTION SYSTEM**

- A. All access hatches and access doors covering openings measuring 12 inches or more in its least dimension through which persons may fall shall be equipped with a fall through prevention system, except where noted on the Contract Drawings. Access hatches and access doors shall be provided with a permanent installed fall through prevention grate system that provides continuous safety assurance in both its closed and open positions. The grate system shall be made with 6061-T6 aluminum or FRP and be designed for a 300 psf minimum liveload, unless noted otherwise.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION**

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.
- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.

### **3.02 INSTALLATION**

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All gratings, access hatches, and access doors shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions. Embedded support frames shall be set level and square.
- C. Grating shall not be field cut or modified unless approved by Engineer.
- D. Grating shall not be used for equipment support or anchorage.

**END OF SECTION**

**SECTION 05 56 00**  
**CASTINGS**

**PART 1 – GENERAL**

**1.01 REQUIREMENT**

- A. Furnish all materials, labor, and equipment required to provide all castings in accordance with the requirements of the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 33 05 61 – Utility Structures
- B. Section 05 10 00 – Metal Materials

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia State Minimum Standard Building Code

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Complete fabrication and erection drawings of all castings specified herein.
  - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

**PART 2 – PRODUCTS**

**2.01 METAL MATERIALS**

- A. Metal materials used for castings shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

**2.02 METAL FASTENING**

- A. All welds and fasteners used for castings shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

## **2.03 IRON CASTINGS**

- A. General - Iron Castings shall include, but not be limited to frames, covers, and grates for trench drains, catch basins, and inlets/.
  - 1. Castings shall be of gray iron of uniform quality, free from defects, smooth and well cleaned by shotblasting.
  - 2. Catalog numbers on the Drawings are provided only to show required types and configuration. All covers shall be cast with raised letters as designated on the Drawings.
  - 3. Castings shall be as manufactured by Dewey Brothers, or Neenah Foundry Company.
- B. Covers and Grates
  - 1. Covers and grates shall be provided with matching frames. Cover shall fit flush with the surrounding finished surface. The cover shall not rock or rattle when loading is applied.
  - 2. Round covers and frames shall have machined bearing surfaces.
  - 3. Design loadings:
    - a. Where located within a structure, a minimum design loading of 300 psf shall be used, unless noted otherwise.
    - b. At all locations not within a structure, the design loading shall be a standard AASHTO H-20 truck loading, unless otherwise noted.
- C. Watertight gasketing, bolting, locking devices, patterns, lettering, pickholes, vents, or self-sealing features shall be as detailed on the Drawings.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION**

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

- C. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

### **3.02 INSTALLATION**

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All castings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

**END OF SECTION**

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**SECTION 05 59 00**  
**BEARING DEVICES AND ANCHORING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENTS**

- A. The Contractor shall furnish and install bearing plates, pads, expansion devices, anchor rods and bolts and/or other devices used in conjunction with bearings and anchoring of bearing devices and assemblies at supports in accordance with this item and in conformity with the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 05 23 – Metal Fastening
- D. Section 05 12 00 – Structural Steel
- E. Section 05 14 00 – Structural Aluminum
- F. Section 09 90 00 – Painting

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of other requirements of these Specifications, all work specified hereunder shall conform to the applicable requirements of the following documents to the extent that the provisions of such documents are not in conflict with the requirements of this Section.
  - 1. RMA Rubber Handbook – A4-F3-T.063-B2, Grade 2, Method B
  - 2. ASTM A240 – Standard Specification for Heat Resisting Chromium and Chromium – Nickel Stainless Steel Plate and Sheet
  - 3. ASTM A480 – Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip
  - 4. ASTM D395 Method B – Standard Test for Rubber Property – Compression Set
  - 5. ASTM D412 – Standard Test for Rubber Properties In Tension
  - 6. ASTM D471 – Standard Test for Rubber Property – Effect of Liquids

7. ASTM D573 – Standard Test for Rubber-Deterioration In Air Oven
8. ASTM D575, Method A – Standard Test for Rubber Properties In Compression
9. ASTM D624, Die C – Standard Test for Rubber Property – Tear Resistance
10. ASTM D746 – Standard Test for Brittleness Temperature of Plastics and Elastomers by Impact
11. ASTM D792 – Standard Test for Specific Gravity and Density of Plastics by Displacement
12. ASTM D1149 – Standard Test for Rubber Deterioration – Surface Ozone Cracking in a Chamber (Flat Specimens)
13. ASTM D1785 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40
14. ASTM D2240 – Standard Test for Rubber Property – Durometer Hardness
15. ASTM D2256 – Standard Test for Breaking Load (Strength) and Elongation of Yarn by the Single-Strand Method
16. ASTM D4894 – Standard Specification for PTFE Granular Molding and RPM Extension Materials
17. ASTM D4895 – Standard Specification for PTFE Resin Produced from Dispersion

#### **1.04 SUBMITTALS**

- A. Submit the following in accordance with the requirements of Section 01 33 00 – Submittal Procedures:
  1. Certification of compliance that the materials furnished under this section meet and conform to the property and physical requirements, including all testing, as stated herein and as referenced. Specifically, the certification shall state compliance with the applicable standards (ASTM, ANSI, etc.) for fabrication and testing.
  2. Shop Drawings for all materials, including installation and adjustment instructions. Included with the Shop Drawings shall be all material certifications, mill test results, working drawings, etc., which are required by this and other applicable sections of the Specifications.

## PART 2 – PRODUCTS

### 2.01 ELASTOMERIC BEARING PADS

- A. The elastomer portion of pads shall be new neoprene compound. Pads shall be cast under heat and pressure and may be individually molded or cut from pressure-cast stock. Variations from the dimensions shown on the Drawings shall not be more than the following: thickness,  $\pm 1/16$  inch; width,  $-1/8$  to  $+1/4$  inch; length,  $-1/8$  to  $+1/4$  inch. Tolerances, dimensions, finish and appearance, flash, and rubber-to-metal bonding shall conform to the requirements of A 4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be furnished in one piece and shall not be laminated unless otherwise specified. Pads shall be furnished in identifiable packages.
- B. Adhesive for use with elastomer pads shall be an epoxy-resin compound compatible with the elastomer having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces. Adhesive shall be 20+F Contact Cement by Miracle Adhesives Corporation, Neoprene Adhesive 77-198 by IGI Adhesives, Sikodur 31, Hi-Mod Gel by Sika Corporation, or DP-605 NS Urethane Adhesive by 3M Adhesive Systems.
- C. Laminated pads shall consist of alternate laminations of elastomer and hot-rolled steel sheets molded together as a unit. Outer metal laminations shall be  $3/16$  inch, and inner laminations shall be 14 gauge. Outer laminations of elastomer shall be  $1/4$  inch, and inner laminations shall be of equal thickness (at least  $3/8$  but not more than  $1/2$  inch), depending on the number of laminations and thickness of the pad. Edges of metal laminations shall have a cover of approximately  $1/8$  inch of elastomer. The top and bottom bearing surfaces shall each have an integral sealing rib approximately  $1/8$  inch in depth, in addition to the specified total thickness, and  $3/16$  inch in width around their peripheries. The bond between the elastomer and metal shall be such that failure shall occur in the elastomer and not between the elastomer and steel when tested for separation. Variations from specified dimensions for individual laminations shall not be more than those specified herein. The total thickness of the complete pad shall not vary more than  $\pm 1/8$  inch.
- D. Material having a nominal durometer hardness of 70 and 50 shall be used for nonlaminated pads and laminated pads, respectively. Test samples will be prepared from finished pads. Samples of each thickness will be taken from 2 full-size pads from each shipment of 300 pads or less, with 1 additional pad for each additional increment of 300 pads or fraction thereof. When tested using the ASTM methods designated, samples shall comply with the following physical requirements:
1. Original Physical Properties: Test results for tear resistance, tensile strength, and ultimate elongation shall not be more than 10 percent below the following specified value:

Nominal	Hardness
50	70

	<b>Nominal 50</b>	<b>Hardness 70</b>
Min. tear resistance, ASTM D624, Die C (lb/in of thickness)	180	200
Hardness, ASTM D2240 (points)	50±5	70±5
Min. tensile strength, ASTM D412 (average psi of longitudinal and transverse)	2,500	2,500
Min. ultimate elongation (%)	400	300

2. The compressive deflection tested in accordance with ASTM D575, Method A, shall be as follows:
  - a. Laminated Pads: The maximum compression deflection shall be 5 and 7 percent of the total rubber thickness at loads of 500 and 800 pounds per square inch, respectively. The maximum shear resistance shall be 50 pounds per square inch of the plan area at 25 percent shear deformation at -20°F. Test pads shall be subjected to a compressive load of 1.5 times the maximum design load without visible damage to the bearing.
  - b. Nonlaminated Pads: When loaded within 300 to 800 pounds per square inch, material shall show a compressive deflection within 20 percent of that given in the charts of Method A, interpolating for actual measured hardness.
3. Changes in Original Physical Properties: When pads are oven aged 70 hours at 212°F in accordance with ASTM D573, changes shall not be more than the following:

<b>Property</b>	<b>Value</b>
Hardness (points change)	0 to +15
Tensile strength (% change)	±15
Ultimate elongation (% change)	-40

4. Extreme Temperature Characteristics: Compression set under constant deflection, ASTM D395, Method B, 22 hours at 212°F, shall not be more than 35 percent. With the low-temperature brittleness test, ASTM D746, breaks shall not occur above -20°F.
5. Ozone Cracking Resistance: Upon exposure to 100 parts per million of ozone in air by volume at a strain of 20 percent and a temperature of 100±2°F in a test otherwise in accordance with ASTM D1149, cracks shall not develop within 100 hours. Samples shall be wiped with solvent before the test to remove traces of surface impurities.

6. Oil Swell: The volume change shall not be more than +120 percent when tested in accordance with ASTM D471 with ASTM Oil No. 3, 70 hours at 212°F.

**2.02 TFE BEARING SURFACES**

- A. TFE resin shall be virgin material conforming to the requirements of ASTM D4894 or D4895. The specific gravity shall be 2.13 to 2.19. The melting point shall be 623±2°F.
- B. Filler material shall be milled glass fibers, carbon, or other approved inert filler materials.
- C. Adhesive material shall be an epoxy resin conforming to FS MMM-A-134, FEB film or equal, as approved by the Engineer.
- D. When tested in accordance with ASTM D4894 or D4895, finished unfilled TFE sheets shall have a tensile strength of at least 2,800 pounds per square inch and an elongation of at least 200 percent.
- E. Filled TFE sheets shall contain inert filler material uniformly blended with TFE resin. Finished filled TFE sheets containing glass fiber or carbon shall conform to the following:

	<b>ASTM Method</b>	<b>15% Glass Fibers</b>	<b>25% Carbon</b>
Min. tensile strength	D4894/D4895	2,000 psi	1,300 psi
Min. elongation	D4894/D4895	150%	75%
Min. specific gravity	D792	2.20	2.10
Melting point	D4894/D4895	327±10°C	317 ±10°C

- F. Fabric containing TFE fibers shall be manufactured from oriented multifilament TFE fluorocarbon fibers and other fibers as required by specific designs. When tested in accordance with ASTM D2256, the tensile strength of TFE fibers shall be at least 24,000 pounds per square inch and the elongation shall be at least 75 percent.
- G. Where TFE sheets are to be epoxy bonded, one surface of the sheet shall be factory treated by an approved manufacturer using the sodium naphthalene or sodium ammonia process.
- H. Stainless steel mating surfaces shall be at least 16 gage in thickness and shall conform to the requirements of ASTM A240, Type 304. The mating surface shall be a true plane surface with a Brinnell hardness of at least 125 and a surface finish of an at least No. 8 mirror finish in accordance with ASTM A480. Stainless steel mating surfaces shall be polished or rolled as necessary to conform to the friction requirements specified herein. The stainless steel shall be attached to the sole plate by means of a seal weld around the entire perimeter of the facing material.

- I. The coefficient of friction for the completed bearing assembly shall not be more than the following:

Material	Bearing Pressure		
	500 psi (3.447 MPa)	2,000 psi (13.790 Mpa)	3,500 psi (24.132 MPa)
Unfilled TFE, fabric Containing TFE fibers, TFE perforated metal composite	.08	.06	.04
Filled TFE	.12	.10	.08
Interlocked bronze and filled TFE structures	.10	.07	.05

### 2.03 PREFORMED FABRIC BEDDING MATERIAL

- A. Material shall be composed of multiple layers of 8-ounce cotton duck impregnated and bound with high-quality natural rubber or its equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be such as to produce the specified thickness after compression and vulcanizing. Finished pads shall withstand compression loads perpendicular to the plane of the laminations of at least 10,000 pounds per square inch without a detrimental reduction in thickness or extrusion.

### 2.04 ANCHOR RODS

- A. Anchor bolts shall be as specified in Section 05 05 23 – Metal Fastening.

### 2.05 PIPE SLEEVES AND COLLARS

- A. Pipe sleeves and collars shall be cut from schedule 40 PVC plastic pipe meeting the requirements of ASTM D1785 unless otherwise noted on the Drawings.

## PART 3 – EXECUTION

### 3.01 STEEL PLATES, SHAPES, AND BARS

- A. Unless galvanizing is indicated on the Drawings, items shall be painted in accordance with the Drawings and Section 09 90 00 – Painting.
- B. If galvanizing is indicated on the Drawings, steel bearing assemblies for both structural steel beams and girders and prestressed concrete members shall be galvanized as specified in Section 05 05 13 – Galvanizing. Except for attachments of bearing plates to beams, all fabrication and welding of bearing plate assemblies shall be performed before the steel is galvanized. All joints of welded parts shall be sealed with weld material. Welds made for attaching bearing plates to beams or girders shall be cleaned and given 2 coats of zinc rich paint having a minimum total coating thickness of 3 mils.

### **3.02 BRONZE PLATES**

- A. Sliding surfaces of bronze plates shall be polished.

### **3.03 COPPER-ALLOY PLATES**

- A. Finishing of rolled copper-alloy plates will not be required provided their surfaces are plane, true, and smooth.

### **3.04 SELF-LUBRICATING PLATES**

- A. Plates shall be fabricated from cast bronze or rolled copper alloy.
- B. Sliding surfaces of plates shall be provided with annular grooves or cylindrical recesses or a combination thereof, which shall be filled with a lubricating compound. The lubricating compound shall be compressed into recesses under sufficient pressure to form a nonplastic lubricating inset. The inset shall comprise at least 25 percent of the total area of the plate. The frictional coefficient shall not be more than 0.10. The compound shall be free from material that will cause abrasive or corrosive action on metal surfaces and able to withstand extremely high pressures and atmospheric elements over long periods of time.
- C. Items shall be the standard products of the manufacturer of such materials for the application.
- D. Prior to assembly, the steel surface that will bear on the self-lubricating bearing plate shall be thoroughly lubricated with additional antioxidant lubricant furnished by the manufacturer. Coatings shall be removed before application of antioxidant lubricant.

### **3.05 ELASTOMERIC PADS**

- A. Care shall be taken in fabricating pads and related metal parts so that effects detrimental to their proper performance, such as uneven bearing and excessive bulging, will not occur.

### **3.06 PLACEMENT OF BEARING PLATES AND PADS**

- A. Bearing areas shall be finished to a true level plane which shall not vary perceptibly from a straightedge placed in any direction across the area.
- B. Bearing plates or pads shall be set level in exact position and shall have a uniform bearing over the entire area. Provision shall be made to keep plates or pads in the correct position during erection of beams or placement of concrete.
- C. Elastomeric pads and other flexible bearing materials shall be placed directly on masonry surfaces finished to a roughness equivalent to that of a No. 36 to No. 46 grit. Pads, bearing areas, or bridge seats and metal bearing plates shall be thoroughly

cleaned and free from oil, grease, and other foreign materials. Metal bearing plates or bottoms of prefabricated beams that are to bear on elastomeric pads shall be coated with epoxy and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit. Bearing areas shall be finished to equivalent roughness.

D. Metal bearing plates shall be bedded on seats as follows:

1. The seat bearing areas shall be thoroughly swabbed with approved paint, and three layers of duck, 12 to 15 ounce per square yard, shall be placed on it, each layer being thoroughly swabbed with paint on its top surface.
2. Superstructure shoes or pedestals shall be placed in position while paint is plastic. As an alternate to duct and paint, preformed fabric bedding material at least 1/8 inch in thickness may be used when called for on the Drawings or approved in writing by the Engineer.

### **3.07 PLACEMENT OF ANCHOR RODS**

- A. All necessary anchor rods and bolts (anchors) shall be accurately set either in the concrete as they are being placed, in formed holes, or in holes cored after the concrete has set. If set in the concrete, the rods and bolts shall be accurately positioned by means of templates and rigidly held in position while the concrete is being placed. Holes may be formed by inserting or casting in the fresh concrete oiled wooden plugs, metal pipe or plastic sleeves, or other approved devices, and withdrawing them after the concrete has partially set or left in place as indicated on the Drawing's or approved by the Engineer. Holes so formed shall be at least 3 inches in diameter or at least 2.5 times the diameter of the rod or bolt. If cored, holes shall be at least 2.5 times the diameter of the anchor used or as indicated on the Drawings. Equipment used for coring concrete shall have been approved by the Engineer. Impact tools will not be permitted. Reinforcing steel shall be placed to provide adequate space to core rod/bolt holes without cutting the reinforcing steel. For cored holes, anchor rods and bolts shall be adequately held in place at the centroid of the hole or as specified on the Drawings by using approved pre-fabricated equalizers designed to allow grout to penetrate and fill the hole completely and spaced as approved by the Engineer.
- B. During freezing conditions, anchor holes shall be protected from water accumulations at all times.
- C. Anchors which are to be placed in holes of sufficient and specified diameter after the concrete has set shall be bonded to the concrete with a non-shrink high-strength Portland cement grout in accordance with Section 03 60 00 – Grout or shall be adhesive anchors in accordance with Section 05 05 23 – Metal Fastening. The type anchoring system and grout shall be as indicated on the Drawings. The grout or adhesive shall completely fill the holes. Anchors shall be tested for sufficient pull-out capacity as indicated in applicable sections of the Specifications or as indicated on the Drawings.



- D. Anchors that are not designed to project through bearing plates shall be checked for proper projection above the masonry bearing area immediately prior to placement of bearing plates and beams. Nuts on anchor rods at expansion ends shall be adjusted to permit free movement of the span.
- E. Angles for anchor assemblies to be attached to sides of concrete beams shall not be installed until beams have received their full dead load and supporting falsework has been removed.

**END OF SECTION**

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**SECTION 07 13 50**  
**WATERPROOFING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of the Work as shown on the Drawings and specified herein.
- B. Principal items of work include:
  - 1. Crystalline waterproofing exterior walls of screenings structure.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 30 00 – Cast-in-Place Concrete

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
  - 1. Manufacturers product literature, specification data sheets and installation instructions.
  - 2. Complete layout and installation drawings and schedules with clearly indicated dimensions.
  - 3. Detail drawings showing all anchoring details and construction details at corners, penetrations and flashing.

**1.04 DELIVERY, STORAGE AND HANDLING**

- A. Deliver materials in manufacturer's unopened containers identified with name, brand, type, grade, class and all other qualifying information.
- B. Store materials in dry location, in such manner as to prevent damage or intrusion of foreign matter. Conspicuously mark "Rejected" on materials which have been damaged and remove from the job site.

## **PART 2 – PRODUCTS**

### **2.01 CRYSTALLINE WATERPROOFING**

- A. Crystalline Waterproofing: Concrete waterproofing material of the cementitious crystalline type that chemically and permanently fixes non-soluble crystalline growth throughout the capillary voids of the concrete. Apply at a rate of 2 lb./sq. yd. Apply second coat while first coat is still green. Crystalline waterproofing shall be as manufactured by Xypex Chemical Corporation, Vandex, HEY'DI K11 by Tamms, or equal.

## **PART 3 – EXECUTION**

### **3.01 EXAMINATION OF SURFACES**

- A. Examine all surfaces and installation of work done by other trades.
- B. Coordinate all work under this Section with contiguous work of other trades.

### **3.02 APPLICATION**

- A. Install crystalline waterproofing in strict accordance with manufacturer's printed instructions and recommendations.
- B. Crystalline waterproofing shall be applied to "green" or existing concrete which has been thoroughly saturated with clean water. Prepare surfaces in strict accordance with manufacturer's recommendations and instructions. Mix and apply in accordance with manufacturer's literature.
- C. Provide a written report from the Manufacturer's representative stating that the crystalline waterproofing was installed correctly.

**END OF SECTION**

**SECTION 07 26 16**  
**VAPOR BARRIER**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish labor, material, equipment and appliances required for complete execution of Work.
- B. Principal items of work include:
  - 1. Vapor barrier below structural slabs on grade.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 30 00 – Cast-in-Place Concrete

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
  - 1. Manufacturer's data and installation instructions.

**PART 2 – PRODUCTS**

**2.01 VAPOR BARRIER**

- A. Vapor Barrier: A reinforced laminate membrane with a minimum tensile strength of 75 lbs/in. in accordance with ASTM D-882, vapor transmission rating of 0.02 perms in accordance with E-96, and a puncture resistance of 25 lbs in accordance with ASTM D-4833.
- B. Adhesive/Tape: Type approved by the Manufacturer of the vapor material.
- C. Penetration sealing: Provide manufacturer's recommended penetration seals at all pipe, conduit, and similar penetrations.

**2.02 ACCEPTABLE MANUFACTURERS**

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
  - 1. Viper Vapercheck 10 by Insulation Solutions, Inc.

2. Griffolyn Type-85, by Reef Industries, Inc.
3. Or Equal

### **PART 3 – EXECUTION**

#### **3.01 VAPOR BARRIER**

- A. Vapor barrier shall be placed on top of 4 inches minimum of compacted structural fill stone, free of debris and protrusions for structural slabs.
- B. Lap edges 12 inches and seal with adhesive tape. Lay with seams perpendicular to and lapped in the direction of placement. Do not penetrate vapor barrier.
- C. Protect from damage until concrete is placed. Punctures and tears in vapor barrier shall be repaired using patches of the material which overlaps puncture or tear a minimum of 12 inches; seal with tape or adhesive.
- D. Penetrations through vapor barrier, such as pipe, drains, conduits and similar penetrations, shall be sealed in strict accordance with manufacturer's recommended instructions.

**END OF SECTION**

**SECTION 07 90 00**  
**JOINT FILLERS, SEALANTS AND CAULKING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish labor, materials, equipment and appliances required for the complete execution of Work shown on the Drawings and specified herein.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 15 00 – Concrete Accessories
- B. Section 03 15 16 – Joints in Concrete
- C. Section 08 80 00 – Glass and Glazing

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. ASTM C-920 – Elastomeric Joint Sealants
  - 2. ASTM D-1056 – Flexible Cellular Materials – Sponge or Expanded Rubber
  - 3. SWRI – Sealant and Caulking Guide Specification

**1.04 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
  - 1. Manufacturers literature and installation instructions.
  - 2. Color samples of each type of sealant.

**1.05 QUALITY ASSURANCE**

- A. Applicator shall be a company specializing in the installation of sealants with a minimum of five years of experience.

## **1.06 DELIVERY, STORAGE AND HANDLING**

- A. Deliver materials in unopened labeled packages.
- B. Store materials in location protected from freezing or damages.
- C. Reject and remove from the site materials within broken or damaged packaging.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

#### **A. Sealants**

1. Type 1: Multi-component, non-sag, low-modulus polyurethane rubber sealant meeting ASTM C-920, Type M, Grade NS, Class 25, use NT, M, A, and O. Capable of withstanding 50% in extension or compression such as Sikaflex-2C NS/SL, Sika Corporation, or Sonolastic NP-2, Sonneborn, or DynaTrol II by Pecora Corporation.
2. Type 2: Single component polyurethane sealant meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, A, and O. Capable of withstanding 25% in extension or compression such as Sikaflex 1A by Sika Corporation, DynaTrol 1-XL by Pecora Corporation, or Sonolastic NP-1 by BASF Construction Chemicals.
3. Type 3: Single component, low-modulus moisture curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Capable of withstanding 50% extension and compression. Pecora 890 by Pecora Corporation, Sonolastic Omni Seal by BASF Construction Chemicals.
4. Type 4: Single component, mildew resistant, moisture-curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Pecora 898 by Pecora Corporation, Sonolastic Omni Plus by BASF Construction Chemicals.
5. Type 5: Single component, acrylic latex meeting ASTM C-834. AC-20+ Silicone by Pecora Corporation, Sonneborn Sonolac by BASF Construction Chemicals.
6. Type 6: High grade butyl sealant meeting Federal Specification TT-S-00-1657. BC-158 by Pecora Corporation or equal.
7. Type 7: Multi-component chemical resistant polysulfide sealant conforming to ASTM C-920, Type M, Grade NS, Class 25 such as Deck-O-Seal by W.R. Meadows, Tammsflex by DuraJoint Concrete Accessories, or Synthacalk GC2+ by Pecora Corporation.



8. Type 8: Nonsag, Multi Component, traffic grade polyurethane sealant meeting ASTM C920, Type 19, Grade NS, Class 25, use T, M, A, and O. DynaTread by Pecora Corporation, Sonolastic Ultra by BASF Construction Chemicals.
- B. Primer: Non-staining primer recommended by sealant manufacturer for the substrates on this project.
- C. Backer Rod: Closed cell foam, nonreactive with caulking materials, non-oily, and approved by the sealant manufacturer. Minimum density shall be 2.00 pounds per cubic foot. Use no asphalt or bitumen-impregnated fiber with sealants.
- D. Joint Cleaner: Recommended by sealant or caulking compound manufacturer.
- E. Bond breaker: Either polyethylene film or plastic tape as recommended by the sealant manufacturer.
- F. Color: Where manufacturer's standard colors do not closely match materials being sealed, provide a custom color.

## **PART 3 – EXECUTION**

### **3.01 QUALITY CONTROL**

- A. Coordinate work with details shown on approved shop drawings prepared by other trades.
- B. Verify conditions in the field.
- C. Schedule work to follow closely the installation of other trades.
- D. Apply sealants and related items in temperatures and dry conditions recommended by the manufacturers.
- E. Do not paint sealant, unless recommended by sealant and paint manufacturer.

### **3.02 PREPARATION**

- A. Protect finished surfaces adjoining by using masking tape or other suitable materials.
- B. Clean and prime joints before starting any caulking or sealing work.
- C. Thoroughly clean joints and spaces of mortar and other foreign materials. Cleaning agent shall be Xylol or similar non-contaminating solvent to remove any film from metal surfaces. Masonry or concrete surfaces shall be brushed or air jet cleaned.
- D. Joint Requirements

1. All joints and spaces to be sealed in exterior work shall be less than 1/2-inch deep and not less than 1/4 inch wide. If joints in masonry are less than that specified herein, the mortar shall be cut out to the required width and depth. All joints and spaces to receive sealant shall be completely prepared and thoroughly dry before installation of sealant.
  
2. Unless otherwise specified, joints and spaces which are open to a depth of 1/2 inch or greater shall be solidly filled with back-up material to within 1/4 inch of the surface. Back-up material shall be packed tightly and made continuous throughout the length of the joints. Bond breaker shall be applied as required. If joints are less than 1/4-inch deep, the back-up material may be omitted, a bond breaker substituted and the joint completely filled with sealant. The back-up material shall not project beyond the 1/4-inch depth of the open space in any joint. The following width-to-depth ratio table shall be adhered to, unless otherwise recommended by manufacturer.

Joint Width	Sealant Depth	
	Minimum	Maximum
1/4 inch	1/4 inch	1/4 inch
Over 1/4 inch to 1/2 inch	1/4 inch	Equal to width
Over 1/2 inch to 1 inch	1/2 inch	Equal to width
Over 1 inch to 2 inches	1/2 inch	1/2 of width

### 3.03 APPLICATION

- A. Exercise care before, during, and after installation so as not to damage any material by tearing or puncturing. All finished work shall be approved before covering with any other material or construction.
  
- B. Apply sealant by an approved type of gun except where the use of a gun is not practicable, suitable hand tools shall be used. Avoid applying the compound to any surface outside of the joints or spaces to be sealed. Mask areas where required to prevent overlapping of sealant.
  
- C. All joints shall be waterproof and weathertight.
  
- D. Point sealed joints to make a slightly concave joint, the edges of which are flush with the surrounding surfaces. Exposed joints in the interior side of the door and other frames shall be neatly pointed flush or to match adjacent jointing work.
  
- E. Adjacent materials which have been soiled shall be cleaned immediately and the work left in neat and clean condition.

- F. Comply with sealant manufacturer's written instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

#### **3.04 ADJUSTMENT AND CLEANING**

- A. Remove misplaced sealant compounds promptly using methods and materials recommended by the manufacturer, as the work progresses.
- B. Allow sealants to cure and remove protective edging, of doors, louvers, saddles windows etc. as directed by the Engineer.

### 3.05 SCHEDULE

#### Schedule of Sealants

Application	Sealant	Color
Vertical and horizontal expansion and construction joints in concrete structures unless noted otherwise herein or on Drawings.	Type 1	To closely match adjacent surfaces or mortar and as selected by the Owner.
Vertical and horizontal joints bordered on both sides by masonry, precast concrete, natural stone or other porous building material, unless noted otherwise herein or on Drawings.	Type 2	To closely match adjacent surfaces or mortar and as selected by the Owner.
Vertical and horizontal joints bordered on both sides by painted metals, anodized aluminum, mill finished aluminum, PVC, glass or other non-porous building material.	Type 3	To closely match adjacent surfaces and as selected by the Owner.
Masonry expansion and control joints less than 1¼" wide.	Type 2	To closely match adjacent surfaces and as selected by the Owner.
Masonry expansion and control joints equal or greater than 1¼ inches wide and not to exceed 2".	Type 1	To closely match adjacent surfaces and as selected by the Owner.
Interior – wood trim and finish joints.	Type 5	Color to be selected by Owner
Sanitary areas, joints in ceramic tile, around plumbing fixtures, countertops, and back splashes. <sup>1</sup>	Type 4	To closely match adjacent surfaces and as selected by the Owner.
Perimeter sealing of doors, windows, louvers, piping, ducts, and electrical conduit. <sup>2</sup>	Type 2 OR Type 3	To closely match adjacent surfaces and as selected by the Owner.
Below thresholds.	Type 6	Manufacturer's standard
Submerged in liquids. <sup>4</sup>	Type 1	Manufacturer's standard
Horizontal Joints exposed to vehicular or pedestrian traffic.	Type 8	To closely match adjacent surfaces.
Other joints indicated on the drawings or customarily sealed but not listed.	Type recommended by manufacturer	To closely match adjacent surfaces and as selected by the Owner.

<sup>1</sup> Sealant for Laboratory Countertop shall be as recommended by countertop manufacturer.

<sup>2</sup> Provide UL approved sealants for penetrations thru fire-rated walls and as specified in Section 07 84 00 - Firestopping.

<sup>3</sup> Sealants which will come in contact with potable water shall meet the requirements of NSF 61.

<sup>4</sup> Where sealant will be immersed in liquid chemicals verify compatibility prior to installation of sealant.

**END OF SECTION**

**SECTION 09 90 00**  
**PAINTING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and Specified herein.
- B. Section Includes:
  - 1. Paint Materials
  - 2. Shop Painting
  - 3. Field Painting
    - a. Surface Preparation
    - b. Piping and Equipment Identification
    - c. Schedule of Colors
    - d. Work in Confined Spaces
    - e. OSHA Safety Colors

**1.02 RELATED SECTIONS**

- A. Section 07 90 00 – Joint Fillers, Sealants, and Caulking

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of these specifications, the Work shall conform to the applicable requirements of the following documents:
  - 1. SSPC – The Society for Protective Coatings Standards
    - a. SSPC-Vis 1 – Pictorial Surface Preparation Standards for Painting Steel Structures
    - b. SSPC-SP2 – Hand Tool Cleaning
    - c. SSPC-SP3 – Power Tool Cleaning
    - d. SSPC-SP5/NACE 1 – White Metal Blast Cleaning

- e. SSPC-SP6/NACE 3 – Commercial Blast Cleaning
  - f. SSPC-SP7/NACE 4 – Brush-off Blast Cleaning
  - g. SSPC-SP10/NACE 2 – Near-White Metal Blast
  - h. SSPC-SP11 – Power Tool Cleaning to Bare Metal
  - i. SSPC-SP13/NACE6 – Surface Preparation of Concrete
- 2. ICRI – International Concrete Repair Institute
  - 3. NACE – National Association of Corrosion Engineers
  - 4. NAFP – The National Association of Pipe Fabricators
  - 5. ASTM D1737 – Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus
  - 6. ASTM B117 – Method of Salt Spray (Fog) Testing
  - 7. ASTM D4060 – Test Method for Abrasion Resistance of Organic Coating by the Taber Abraser
  - 8. ASTM D3359 – Method for Measuring Adhesion by Tape Test

#### **1.04 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
  - 1. Manufacturer's literature and Material Safety Data Sheets for each product.
  - 2. Painting schedule identifying surface preparation and paint systems proposed. Cross-reference with Tables 9-1 and 9-2. Provide the name of the paint manufacturer, and name, address, and telephone number of manufacturer's representative who will inspect the work. Submit schedule for approval as soon as possible following the Award of Contract, so approved schedule may be used to identify colors and specify shop paint systems for fabricated items.

#### **1.05 SYSTEM DESCRIPTION**

- A. Work shall include surface preparation, paint application, inspection of painted surfaces and corrective action required, protection of adjacent surfaces, cleanup and appurtenant work required for the proper painting of all surfaces to be painted. Surfaces to be painted are designated within the Painting Schedule and may include new and existing piping, miscellaneous metals, equipment, buildings, exterior fiberglass, exposed electrical conduit and appurtenances.

- B. Perform Work in strict accordance with manufacturer's published recommendations and instructions, unless the Engineer stipulates that deviations will be for the benefit of the project.
- C. Paint surfaces which are customarily painted, whether indicated to be painted or not, with painting system applied to similar surfaces, areas and environments, and as approved by Engineer.
- D. Piping and equipment shall receive color coding and identification. Equipment shall be the same color as the piping system.

#### **1.06 QUALITY ASSURANCE**

- A. Painting operations shall be accomplished by skilled craftsman and licensed by the state/commonwealth to perform painting work.
- B. Provide a letter indicating that the painting applicator has five years of experience, and 5 references which show previously successful application of the specified or comparable painting systems. Include the name, address, and the telephone number for the Owner of each installation for which the painting applicator provided services.

#### **1.07 STORAGE AND DELIVERY**

- A. Bring materials to the job site in the original sealed and labeled containers.
- B. Container label to include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- C. Store paint materials at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

### **PART 2 – MATERIALS**

#### **2.01 GENERAL INFORMATION**

- A. The term "paint" is defined as both paints and coatings including emulsions, enamels, stains, varnishes, sealers, and other coatings whether organic or inorganic and whether used as prime, intermediate, or finish coats.
- B. Purchase paint from an approved manufacturer. Manufacturer shall assign a representative to inspect application of their product both in the shop and field. The manufacturer's representative shall submit a report to the Engineer at the completion the Work identifying products used and verifying that surfaces were properly prepared,

products were properly applied, and the paint systems were proper for the exposure and service.

- C. Provide primers and intermediate coats produced by same manufacturer as finish coat. Use only thinners approved by paint manufacturer, and only within manufacturer's recommended limits.
- D. Ensure compatibility of total paint system for each substrate. Test shop primed equipment delivered to the site for compatibility with final paint system. Provide an acceptable barrier coat or totally remove shop applied paint system when incompatible with system specified, and repaint with specified paint system.
- E. Use painting materials suitable for the intended use and recommended by paint manufacturer for the intended use.
- F. Require that personnel perform work in strict accordance with the latest requirements of OSHA Safety and Health Standards for construction. Meet or exceed requirements of regulatory agencies having jurisdiction and the manufacturer's published instructions and recommendations. Maintain a copy of all Material Safety Data Sheets at the job site of each product being used prior to commencement of work. Provide and require that personnel use protective and safety equipment in or about the project site. Provide respiratory devices, eye and face protection, ventilation, ear protection, illumination and other safety devices required to provide a safe work environment.

## **2.02 ACCEPTABLE MANUFACTURERS**

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
  - 1. Tnemec Company Inc.
  - 2. Ameron
  - 3. CARBOLINE
  - 4. Sherwin-Williams

## **PART 3 – EXECUTION**

### **3.01 SHOP PAINTING**

- A. Shop prime fabricated steel and equipment with at least one shop coat of prime paint compatible with finish paint system specified. Prepare surface to be shop painted in strict accordance with paint manufacturer's recommendations and as specified. Finish coats may be shop applied, if approved by the Engineer. Package, store and protect shop painted items until they are incorporated into Work. Repair painted surfaces damaged



during handling, transporting, storage, or installation to provide a painting system equal to the original painting received at the shop.

- B. Identify surface preparation and shop paints on Shop Drawings. Verify compatibility with field applied paints.

### **3.02 SURFACE PREPARATION**

#### **A. General**

1. Surfaces to be painted shall be clean and dry, and free of dust, rust, scale, and foreign matter. No solvent cleaning, power or hand tool cleaning shall be permitted unless approved by the Engineer.
2. Protect or remove, during painting operations, hardware, accessories, machined surfaces, nameplates, lighting fixtures, and similar items not intended to be painted prior to cleaning and painting. Reposition items removed upon completion of painting operations.
3. Examine surfaces to be coated to determine that surfaces are suitable for specified surface preparation and painting. Report to Engineer surfaces found to be unsuitable in writing. Do not start surface preparation until unsuitable surfaces have been corrected. Starting surface preparation precludes subsequent claim that such surfaces were unsuitable for the specified surface preparation or painting.
4. Surface preparation shall be in accordance with specifications and manufacturer's recommendations. Provide additional surface preparation, and fill coats where manufacturer recommends additional surface preparation, in addition to requirements of specification.
5. Touch-up shop or field applied coatings damaged by surface preparation or any other activity, with the same shop or field applied coating; even to the extent of applying an entire coat when required to correct damage prior to application of the next coating. Touch-up coats are in addition to the specified applied systems, and not considered a field coat.
6. Protect motors and other equipment during blasting operation to ensure blasting material is not blown into motors or other equipment. Inspect motors and other equipment after blasting operations and certify that no damage occurred, or where damage occurred, the proper remedial action was taken.
7. Field paint shop painted equipment in compliance with Color Coding and as approved by Engineer.

#### **B. Metal Surface Preparation**

1. Prepare all welds to a minimum NACE weld preparation level "C" per NACE Standard SP0178. Provide additional weld preparation where required by the coating manufacturer. Contractor shall provide NACE SP0178 weld mold visual aids on site for evaluation of all weld preparation.
2. Conform to current The Society for Protective Coatings Standards (SSPC) Specifications for metal surface preparation. Use SSPC-Vis-1 pictorial standards or NACE visual standards TM-01-70 or TM-01-75 to determine cleanliness of abrasive blast cleaned steel.
3. Perform blast cleaning operations for metal when following conditions exist:
  - a. Moisture is not present on the surface.
  - b. Relative humidity is below 80%.
  - c. Ambient and surface temperatures are 5°F or greater than the dew point temperature.
  - d. Painting or drying of paint is not being performed in the area.
  - e. Equipment is in good operating condition.
  - f. Proper ventilation, illumination, and other safety procedures and equipment are being provided and followed.
4. Abrasive blast ferrous metals to be shop primed, or component mechanical equipment in accordance with SSPC-SP5, White Metal Blast.
5. Abrasive blast field prepared ferrous metals in accordance with SSPC-SP10, Near White Metal Blast, where metal is to be submerged, in a corrosive environment, or in severe service. Provide a 3.0 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
6. Abrasive blast field prepared ferrous metals in accordance with SSPC-SP6 Commercial Blast, where metal is to be used in mild or moderate service, or non-corrosive environment. Provide a 1.5 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
7. Clean nonferrous metals, copper, or galvanized metal surfaces in accordance to SSPC-SP1, Solvent Cleaning, or give one coat of metal passivator or metal conditioner compatible with the complete paint system. Abrasive blast clean to increase mechanical adhesion in accordance with ASTM D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting when required by coating manufacturer. Provide a 1.5 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.

8. Abrasive blast clean internal and external ductile iron pipe surfaces prior to coating in accordance with NAPF 500-03-04, Surface Preparations Standard for Abrasive Blast Cleaning of Ductile Iron Pipe. Abrasive blast clean internal and external cast ductile iron and cast-iron fitting surfaces in accordance with NAPF-03-05.
9. Prime cleaned metals immediately after cleaning to prevent rusting.
10. Clean rusted metals down to bright metal by abrasive blasting and immediately field primed.

#### C. Concrete Surface Preparation

1. Cure concrete a minimum of 28 days at 75° F before surface preparation, and painting begins. Allow more time at lower temperatures if specified by paint manufacturer.
2. Test concrete for pH and salts using test methods recommended by the paint manufacturer. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer. Do not begin surface preparation, or painting until acceptable to manufacturer.
3. Moisture content of concrete and masonry surfaces shall conform to manufacturer's recommended limits, and as listed in SSPC-SP13/NACE 6 Section 6 Acceptance Criteria Table 1. Floor surfaces to be coated shall be tested in accordance with ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride or as required by the coating manufacturer. Moisture vapor transmission shall not exceed three pounds per 1,000 square feet in a 24-hour period or less if specified by Coating Manufacturer. Vertical and horizontal overhead surfaces shall be tested in accordance with ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete using in situ Probes (relative humidity shall not exceed 80% or as required by the coating manufacturer) or with ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Test Method (test results shall be no moisture present). Engineer or Coating Manufacturer Representative shall specify all test locations. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer.
4. Prepare concrete surfaces to receive coatings in accordance with NACE 6/SSPC-13 – Joint Surface Preparation Standards and ICRI Technical Guidelines. Remove contaminants, open bugholes, surface voids, air pockets, and other subsurface irregularities using abrasive blasting, shot blasting, water jetting or mechanical abrading. Use dry, oil-free air for blasting operations. Surface texture after blasting shall achieve profile as required by manufacturer or where not defined by manufacturer, profile shall be a minimum ICRI-CSP 5 surface profile. Remove

residual abrasives, dust, and loose particles by vacuuming or other approved method.

5. Surface defects, such as hollow areas, bugholes, honeycombs, and voids shall be filled with polymeric filler compatible with painting system. Complete fill coats may be used in addition to specified painting system and as approved by the Engineer. Fins, form marks, and all protrusions or rough edges shall be removed.
6. Repair existing concrete surfaces which are deteriorated to the point that surface preparation exposes aggregate with fill coats or patching mortar as recommended by paint manufacturer and as directed by the Engineer.
7. Clean concrete of all dust, form oils, curing compounds, oil, tar, laitance, efflorescence, loose mortar, and other foreign materials before paints are applied.
8. To ease coating around outside corners, provide  $\frac{3}{4}$ -inch chamfered edges on all new concrete outside corners and grind existing concrete outside corners to a minimum radius of  $\frac{3}{4}$ -inch.
9. Unless recommended otherwise by the coating manufacturer, provide  $\frac{1}{4}$ " deep by  $\frac{1}{4}$ " wide tool cut terminations at 1-inch maximum from all coating edges for anchorage. Provide terminations around all equipment, piping, openings, gates, top and bottom of walls, stop locations of each day's work and overlap onto previously completed work. Transition coating 3-inches onto interior lining of piping except where coating compatibility concerns are noted by coating manufacturer.
10. Apply epoxy or polymeric filler compatible with painting system to all inside corners of areas to be coated with a margin trowel to form a continuous 45-degree cant cove across corners with a minimum dimension of 1.5-inch. Roughen or prepare cured filler as recommended by coating manufacturer for proper coating adhesion.
11. All equipment grouting shall be installed and cured prior to starting coating work. Coating shall be applied over grout up to the edges of all equipment, gates and uninterrupted piping unless specifically noted otherwise.

#### D. Castings

1. Prepare castings for painting by applying a brush or a knife-applied filler. Fillers are not to be used to conceal cracks, gasholes, or excessive porosity.
2. Apply one coat of primer with a minimum thickness of 1.2 mils in addition to coats specified. Allow sufficient drying time before further handling.

#### E. Previously-Painted Surfaces

1. Totally remove existing paint when: surface is to be submerged in a severe environment, paint is less than 75% intact, brittle, eroded or has underfilm rusting.
2. Surfaces which are greater than 75% intact require removal of failed paints and then spot primed. Spot priming is in addition to coats specified.
3. Remove surface contamination such as oil, grease, loose paint, mill scale, dirt, foreign matter, rust, mold, mildew, mortar, efflorescence, and sealers.
4. Clean and dull glossy surfaces prior to painting in accordance with the manufacturer's recommendations.
5. Check existing paints for compatibility with new paint system. If incompatible, totally remove existing paint system or apply a barrier coat recommended by the paint manufacturer. Remove existing paints of undetermined origin. Prepare a test patch of approximately 3 square feet over existing paint. Allow test patch to dry thoroughly and test for adhesion. If proper adhesion is not achieved remove existing paint and repaint.

### 3.03 APPLICATION OF PAINT

- A. Apply paint by experienced painters with brushes or other applicators approved by the Engineer, and paint manufacturer.
- B. Apply paint without runs, sags, thin spots, or unacceptable marks.
- C. Apply at rate specified by the manufacturer to achieve at least the minimum dry mil thickness specified. Apply additional coats, if necessary, to obtain thickness.
- D. Special attention shall be given to nuts, bolts, edges, angles, flanges, etc., where insufficient film thicknesses are likely. Stripe paint prior to applying prime coat. Stripe painting shall be in addition to coats specified.
- E. Perform thinning in strict accordance with the manufacturer's instructions, and with the full knowledge and approval of the Engineer and paint manufacturer.
- F. Allow paint to dry a minimum of twenty-four hours between application of any two coats of paint on a particular surface, unless shorter time periods are a requirement by the manufacturer. Longer drying times may be required for abnormal conditions as defined by the Engineer and paint manufacturer. Do not exceed manufacturer's recommended drying time between coats.
- G. Suspend painting when any of the following conditions exist:
  1. Rainy or excessively damp weather.

2. Relative humidity exceeds 85%.
  3. General air temperature cannot be maintained at 50°F or above through the drying period, except on approval by the Engineer and paint manufacturer.
  4. Relative humidity will exceed 85% or air temperature will drop below 40°F within 18 hours after application of paint.
  5. Surface temperature of item is within 5 degrees of dewpoint.
  6. Dew or moisture condensation are anticipated.
  7. Surface temperature exceeds the manufacturer's recommendations.
- H. Where application of coating across concrete control joints or expansion joints has the potential to crack, turn coating into joints and caulk joints with a sealant compatible with coating rated for the intended service per Section 07 90 00 – Joint Fillers, Sealants, Caulking.

### **3.04 INSPECTION**

- A. Each field coat of paint will be inspected and approved by the Engineer or his authorized representative before succeeding coat is applied. Tint successive coats so that no two coats for a given surface are exactly the same color. Tick-mark surfaces to receive black paint in white between coats.
- B. Use magnetic dry film thickness gauges and wet fiber thickness gauges for quality control. Furnish magnetic dry film thickness gauge for use by the Engineer.
- C. Coatings shall pass a holiday detector test.
- D. Determination of Film Thickness: Randomly selected areas, each of at least 107.5 contiguous square feet, totaling at least 5% of the entire control area shall be tested. Within this area, at least 5 squares, each of 7.75 square inches, shall be randomly selected. Three readings shall be taken in each square, from which the mean film thickness shall be calculated. No more than 20 percent of the mean film thickness measurements shall be below the specified thickness. No single measurement shall be below 80 percent of the specified film thickness. Total dry film thickness greater than twice the specified film thickness shall not be acceptable. Areas where the measured dry film thickness exceeds twice that specified shall be completely redone unless otherwise approved by the Engineer. When measured dry film thickness is less than that specified additional coats shall be applied as required.
- E. Holiday Testing: Holiday test painted ferrous metal surfaces which will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures. Mark areas which contain holidays. Repair or repaint in accordance with paint manufacturer's printed instructions and retest.

1. Dry Film Thickness Exceeding 20 Mils: For surfaces having a total dry film thickness exceeding 20 mils: Pulse-type holiday detector such as Tinker & Razor Model AP-W, D.E. Stearns Co. Model 14/20, shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.
  2. Dry Film Thickness of 20 Mils or Less: For surfaces having a total dry film thickness of 20 mils or less: Tinker & Razor Model M1 non-destructive type holiday detector, K-D Bird Dog, shall be used. The unit shall operate at less than 75-volts. For thicknesses between 10 and 20 mils, a non-sudsing type wetting agent, such as Kodak Photo-Flow, shall be added to the water prior to wetting the detector sponge.
- F. Paint manufacturer or his representative shall provide their services as required by the Engineer. Services shall include, but not be limited to, inspecting existing paint, determination of best means of surface preparation, inspection of completed work, and final inspection of painted work 11 months after the job is completed.

### **3.05 PROTECTION OF ADJACENT PAINT AND FINISHED SURFACES**

- A. Use covers, masking tape, other method when protection is necessary, or requested by Owner or Engineer. Remove unwanted paint carefully without damage to finished paint or surface. If damage does occur, repair the entire surface adjacent to and including the damaged area without visible lapmarks and without additional cost to the Owner.
- B. Take all necessary precautions to contain dispersion of sandblasting debris and paint to the limits of the work. Take into account the effect of wind and other factors which may cause dispersion of the sandblasting debris and paint. Suspend painting operations when sanding debris or paint cannot be properly confined. Assume all responsibilities and cost associated with damage to adjacent structures, vehicles, or surfaces caused by the surface preparation and painting operations.

### **3.06 SCHEDULE OF COLORS**

- A. Colors shall be selected from the manufacturer's full range of colors by the Engineer. No variation shall be made in colors without the Engineer's approval. Color names and numbers shall be identified according to the appropriate color chart issued by the manufacturer of the particular product in question.

### **3.07 WORK IN CONFINED SPACES**

- A. Provide and maintain safe working conditions for all employees. Supply fresh air continuously to confined spaces through the combined use of existing openings, forced-draft fans and temporary ducts to the outside, or direct air supply to individual workers. Exhaust paint fumes to the outside from the lowest level in the contained space. Provide explosion-proof electrical fans, if in contact with fumes. No smoking or

open fires will be permitted in, or near, confined spaces where painting is being done. Follow OSHA, state/commonwealth, and local regulations at all times.

### **3.08 OSHA SAFETY COLORS**

- A. Paint wall around wall-mounted breathing or fire apparatus with the appropriate safety red color; area not exceed 2-feet wide by 3-feet high, unless apparatus covers the area. Fire apparatus include fire hoses, extinguisher, and hydrants.
- B. Paint hazardous areas and objects in accordance with OSHA regulations.



**Table 1: Painting Schedule**

Surface	Application	Painting System and No. of Coats	Product Reference (Table 2)	Total Min. Dry Film Thickness (Mils)
<b>Concrete and Masonry</b>				
Interior concrete walls and ceilings	All new structures, except Screening Structure and Wet Well	1 coat sealer 2 coats acrylic epoxy	101 116	75-85 sq.ft./gal. 4-6/coat
Interior and concrete walls and ceilings	Wet Well (unlined, nonsubmerged interior surfaces)	See Section 09 96 59	See Section 09 96 59	See Section 09 96 59
Submerged wastewater	Screening Structure, Wet Well Invert Fill	See Section 09 96 59	See Section 09 96 59	See Section 09 96 59
<b>Metals</b>				
Interior and exterior nonsubmerged (gloss)	All new pumps, motors and mechanical equipment, piping, etc.	1 coat epoxy polyamide primer	104	4-6
		1 coat epoxy polyamide	102	4-6
		1 coat aliphatic polyurethane	115	3-5
Interior insulated		1 coat acrylic latex	103	4
Submerged Wastewater		2 coats high solids epoxy	119	8-10/coat
Steel doors, windows and door frames, steel stairs, monorails, structural steel, misc. metals (steel)		1 coat epoxy polyamide	102	5-8
		1 coat aliphatic polyurethane	115	3-4
Aluminum surfaces in contact with concrete		2 coats coal tar	107	26
<b>Other</b>				
Interior: Tar-dipped piping where color is required		2 coats epoxy resin sealer	112	5-8/coat
		2 coats epoxy polyamide	102	5-8/coat
PVC Piping		1 coat epoxy polyamide	102	5-8
		1 coat aliphatic polyurethane	115	3-4

1 Painting manufacturer shall verify compatibility of containment liner and chemical to be contained. Where incompatible substitute a compatible coating system.

**Table 2: Product Listing**

Ref.	System	Purpose	Product			
			Tnemec Series	PPG/AMERON	CARBOLINE	Sherwin-Williams
101	Acrylic filler	Primer-sealer	130-6601	BLOXFIL 4000	Sanitile 100	Cement-Plex 875
102	Epoxy polyamide	Finish coat semi-gloss or gloss	N69	AMERLOCK 2	Carboguard 890	Dura-Plate 235
103	Acrylic latex	Sealer	1028/1029	PITT TECH PLUS	Carbocrylic 3359DTM	DTM Acrylic Primer/Finish
104	Epoxy Polyamide – metal	Primer	66	AMERCOAT 385	Carboguard 893SG	Macropoxy 646
105	Epoxy	Primer/Finish	20	AMERLOCK 2	Carboguard 561/56LT	Macropoxy 646 PW
106	Coal tar epoxy	Finish high-coat build	46H-413	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
107	Coal tar	Sealer	46-465	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
108	Alkyd-medium oil	Finish coat	2H	DEVGUARD 4308	Carbocoat 8215	Industrial Enamel
109	Alkyd-long oil	Finish coat	1029	DEVGUARD 4308	Carbocoat 8215	Industrial Enamel
110	Epoxy polyamide	Primer	66-1211	AMERCOAT 385	Carboguard 893SG	Macropoxy 646
112	Epoxy polyamide	Sealer	66-1211	AMERCOAT 385	Carboguard 893SG	Macropoxy 920 Pre-Prime
113	Urethane	Barrier coat	530	AMERLOCK SEALER	Rustbond	-
114	Polyamine Epoxy	Intermediate coat	27	AMERLOCK 385	Carboguard 893SG	-
115	Aliphatic Polyurethane	Finish coat	1074 or 1075	AMERCOAT 450 HS	Carbothane 134HG	Acrolon 218HS
116	Acrylic epoxy	Finish coat	113 or 114	AQUAPON WB	Sanitile 255	Water-Based Catalyzed Epoxy
117	Epoxy block filler	Sealer	1254	AMERLOCK 114	Sanitile 600	Kem Cati-Coat HS Epoxy Filler
118	Catalyzed epoxy	Finish coat	84	AMERLOCK 2/400	Carboguard 890	Macropoxy 646
119	High solids epoxy	Finish coat	104	AMERLOCK 400	Carboguard 890	Dura-Plate 235
120	Epoxy	Top coat	N69	AMERLOCK 2/400	Carboguard 890	-

**END OF SECTION**

**SECTION 09 96 59**  
**EPOXY MIC COATING SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENTS**

- A. Furnish and install special coating systems in accordance with the Contract Documents.
- B. MIC Coating System
  - 1. Install Microbiologically Influenced Corrosion (MIC) coating system where shown on the drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 15 00 – Concrete Accessories
- B. Section 03 35 00 – Concrete Finishes
- C. Section 03 60 00 – Grout
- D. Section 03 01 30 – Concrete Repairs
- E. Section 07 90 90 – Joint Fillers, Sealants and Caulking
- F. Section 09 90 00 – Painting

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of these Specifications, the Work shall conform to the applicable requirements of the following documents:
  - 1. SSPC-SP13/NACE No. 6 – Surface Preparation of Concrete
  - 2. NACE – National Association of Corrosion Engineers
  - 3. SSPC – The Society of Protective Coatings
  - 4. ASTM – American Society of Testing and Materials
  - 5. ICRI – International Concrete Repair Institute

## 1.04 SUBMITTALS

- A. Shop Drawings including the following items shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
1. Manufacturer's product data and material safety data sheets for each coating product provided. Include manufacturer's color chart for each product supplied.
  2. Manufacturer's installation instructions and recommendations specific to environmental conditions, surface preparation, substrate conditions, and application procedures.
  3. Complete shop drawings including location and details for all terminations, transitions, and can't coves.
  4. Manufacturer's instructions and recommendations for repair of holiday or other coating issues.
  5. Certifications:
    - a. Furnish affidavits from the manufacturer certifying that materials furnished conform to the requirements specified.
    - b. Certify concrete repair and coating products have been checked for compatibility.
    - c. Certification from manufacturer stating the applicator and applicator's assigned personnel are certified and have received specific training for the application of the MIC coating system.
    - d. Certificate from applicator stating the assigned personnel have received specific training for the application of the MIC coating system.
    - e. Submit manufacturer's representative or independent inspector's NACE or SSPC certification.
  6. Submit manufacturer's representative name, address and telephone number who will inspect work.
  7. Provide list of at least 10 applications in high H2S environments in Southeast States including contact names, address, phone numbers and date of installation for both the coating system and the applicator.
  8. Field Data Records and Installation Reports.
  9. Product Warranty.

10. Closeout Submittals:

- a. As-built drawings which include coating application limits, transitions, and terminations.
- b. Photos
- c. Quality assurance records, field data records and installation reports
- d. Certificate of Surface Preparation
- e. Test and evaluation reports including pull-off strength (adhesion) and high voltage spark testing.
- f. Final Report
- g. Final Certified Warranty

**1.05 QUALIFICATIONS**

- A. Products shall be manufactured by company specializing in manufacturing the products specified in this section with a minimum of five continuous years of experience for performance in similar applications in wastewater treatment plants and wastewater collection systems.
- B. The Contractor performing the work shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner and shall be an approved installer of the coating system as certified and licensed by the manufacturer. The Contractor shall have successfully installed a minimum of 50,000 square feet of the proposed system and shall have a minimum of five (5) years of service for applying the selected lining or coating system as documented by verifiable references. There shall be no exceptions to this experience requirement. The Contractor shall submit the following information to the Engineer for review and approval before any work is performed. The following information is required.
  1. The number of years of experience in performing this type of specialized work and in installing the specified coating system.
  2. Name of the manufacturer and supplier for this work and previous work listed below.
  3. A list of municipal clients that the Contractor has performed this type of work including names, phone numbers, and square feet of material installed.
  4. The Contractor shall submit a certified statement from the manufacturer that he/she is a certified and/or licensed installer of the coating.

## 1.06 QUALITY ASSURANCE

- A. The supplier shall be responsible for the provisions of all test requirements specified in the referenced ASTM Standards as applicable. The supplier shall also bear the cost of all tests specified in Paragraph 3.05, Field Testing and Acceptance of MIC Coating System. In addition, all coating products to be installed under this Contract may be inspected at the plant for compliance with these specifications by an independent testing laboratory provided by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of plant inspection of all products and materials approved for this Contract shall be borne by the Owner.
  
- B. Inspections of the coating products and materials may also be made by the Engineer or other representatives of the Owner after delivery. The products and materials shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though samples may have been accepted as satisfactory at the place of manufacture. Materials rejected after delivery shall be marked for identification and shall be removed from the job at once.
  - 1. Provide adequate time and access for inspections for the following major activities:
    - a. Pre-surface preparation
    - b. Monitoring of surface preparation
    - c. Post-surface preparation
    - d. Monitoring of repair and resurfacing product application
    - e. Post repair and resurfacing products
    - f. Monitoring of coating application
    - g. Post application inspection and testing
    - h. Corrective actions and final inspection
  
- C. Pre-installation Meeting
  - 1. At least two weeks prior to beginning work, the Contractor shall conduct a Pre-installation Meeting to discuss coating procedures and submittals. Attendees shall include the Coating Applicator, Owner, Engineer, Manufacturer's Technical Representative, Testing and Inspection Agencies (if applicable), Concrete Repair subcontractor (if applicable) and the Contractor. The minimum agenda includes:
    - a. Environmental condition requirements
    - b. Surface temperature requirements

- c. Surface pH requirements
- d. Surface preparation procedures
- e. Cleaning procedures
- f. Testing procedures to determine moisture content of concrete
- g. Proper procedures to fill substrate
- h. Application equipment
- i. Proper application of primer
- j. Proper application of coating system
- k. Proper termination, transition, and cant cove details
- l. Coating application at concrete control joints and expansion joints
- m. Inspection of coating during and after application
- n. Testing of coating.
- o. Repair methods
- p. Documentation requirements
- q. Approval Procedures

D. Field Data Records

- 1. Maintain daily Quality Assurance Records including the following:
  - a. Date
  - b. Atmospheric Temperature and Humidity
  - c. Substrate pH
  - d. Substrate Temperature
  - e. Dew Point
  - f. Product Batch Numbers
  - g. Mixing Time for Each Part and the Combined Parts of a Coating System

- h. Pot Life
- i. Curing Time of Primer and Finish Layers
- j. Holiday Test Results and Repair Data
- k. Foreman or Supervisor's Signature

#### **1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE**

- A. Provide the services of a qualified manufacturer's technical representative who shall adequately supervise the surface preparation and application of the coating and lining products. The manufacturer's representative shall be available to evaluate the coating at each step through the process and shall supervise the lining or coating application until the installer has shown through the proper surface preparation and application of the lining or coating that the system will be installed in accordance with all manufacturer recommendations. ICRI Concrete Surface Profile Sample Chips shall be used for evaluation of concrete surface profiles and cleaning. NACE Standard SP0178 with weld mold visual aids shall be used for evaluation of weld preparation for coatings where applied to metals. SSPC VIS Guides shall be used for evaluation of metal surface profiles and cleaning. Contractor shall have all sample chips and visual guides on site during evaluation of surface preparation.
- B. Manufacturer's technical representative or authorized inspector shall be currently certified by NACE.
- C. A manufacturer's technical representative shall observe the application of the complete system a minimum of two days at the beginning of the application at each structure specified to receive MIC coating system. The manufacturer's technical representative shall provide guidance to ensure proper application of the system.
- D. The manufacturer's technical representative shall submit to the Engineer a final report, at the completion of the work, identifying the products used, verifying and certifying that surfaces and lining systems were properly applied, free of pinholes, blisters and other blemishes that will compromise the coating performance and that the coating systems were proper for the exposure and surface. Discrepancies that are found during the final inspection shall be repaired and reinspected until system is completely satisfactory.

#### **1.08 DELIVERY, STORAGE AND HANDLING**

- A. Care shall be taken in shipping, handling and placing to avoid damaging the products. Extra care may be necessary during cold weather construction. Any product or material damaged in shipment shall be replaced as directed by the Engineer.



- B. All products shall be new materials and shall be delivered to the site in clearly labeled containers and packaging. While stored, the products shall be adequately packaged and protected. Products shall be stored in a manner as recommended by manufacturer.
- C. Any product showing deterioration, or which has been exposed to any other adverse storage condition that may have caused damage, even though no such damage can be seen, shall be marked as rejected and removed at once from the work.

## **1.09 WARRANTY**

- A. All lining and coatings installed shall be guaranteed by the Contractor for a period of two years from the date of final acceptance. During this period, all defects discovered in the coating, as determined by the Owner or Owner's Engineer shall be repaired or replaced in a satisfactory manner by the Contractor at no cost to the Owner.
- B. The Contractor is responsible for properly preparing the structures for coating prior to the installation of the systems, including stopping all leaks, patching voids, protecting or removing and handling all mechanical equipment such as valves and valve assemblies and weirs, cleaning surfaces, removing rubble, etc.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. MIC coating shall be installed in locations as specified on drawings with system as specified in Table 1.

### **2.02 PATCHING/RESURFACING MATERIAL**

- A. Patching and resurfacing material shall be self-priming, high performance, aggregate reinforced, epoxy modified cement mortar as recommended by the coating manufacturer.

### **2.03 PRIMER**

- A. Primer shall be moisture tolerant, suitable for the environmental conditions, and compatible with the MIC coating. When required by manufacturer to facilitate holiday testing, primer shall be conductive for purposes of holiday testing, shall meet the requirements of NFPA 99/ASTM F150 and shall comply with the requirements for conductive underlayments in ASTM D4787, Standard Practice for Continuity Verification of Liquid or Sheet Linings applied to Concrete Surfaces. Primer shall be as recommended and preferably manufactured by the manufacturer of the MIC Coating System. If approved by manufacturer, MIC Coating System can be self-priming.

- B. Primer shall be as recommended by the coating manufacturer to achieve a superior coating system performance. Manufacturer shall select primer based on substrate moisture, environmental conditions and humidity, substrate temperature, pH, and other properties.

#### **2.04 MIC COATING SYSTEM**

- A. Provide MIC Coating System on surfaces indicated to receive MIC Coatings in this specification and on drawings. MIC Coating System is to be applied only by Factory Trained and Certified Applicators.
- B. The MIC Coating shall be an epoxy mortar system such as Raven 405 as manufactured and applied by Raven Lining Systems. Additional approved systems include: Sauereisen Sewergard 210S; Sherwin-Williams, Dura-Plate 5900 or 6100; and Tnemec Series 434 top coated with Series 435.
- C. The MIC Coating shall be applied in one or two coats, as recommended by MIC Coating manufacturer, for a total DFT of 100 to 120 mils. In addition to MIC Coating, fill bugholes, depressions, and irregularities in surfaces with any dimension greater than 0.0625 inch with epoxy filler recommended by manufacturer and apply primer at 10 mils recommended by manufacturer to achieve superior performance.
- D. MIC Coating System shall meet the following minimum characteristics:
  - 1. Total Film Thickness of System including primers shall not be less than 100 mils (unless otherwise noted).
  - 2. Chemical Resistance of 10% of sulfuric acid.
  - 3. Water Vapor Permeance of 0.002 perms per ASTM E96, Method E.
  - 4. Concrete Tensile Pull Strength 350 psi ASTM D4541.
  - 5. Tensile Strength of 2,750 psi ASTM D412.
  - 6. Abrasion Resistance, CS17 Wheel <120mg loss, ASTM D4060, 1000 gm load/1000 cycles.
  - 7. Minimum Shore Hardness D50, ASTM D2240.
  - 8. Resistant to negative water infiltration.
  - 9. 100% solids epoxy mortar system containing aggregate and/or fiber reinforcement.

## **PART 3 – EXECUTION**

### **3.01 PROTECTION OF IN-PLACE CONDITIONS**

- A. Equipment, vehicles, buildings, and other finished items shall be protected from damage and overspray. Sensitive equipment shall be wrapped in plastic and tape.

### **3.02 SURFACE PREPARATION**

- A. Surfaces to receive coating shall be clean and free of dirt, oil, grease, and other foreign materials.
- B. Concrete and masonry surfaces shall cure for 28 days minimum at 75° F prior to coating. Moisture content of concrete and masonry surfaces shall conform to manufacturer's recommended limits, and as listed in SSPC-SP13/NACE 6 Section 6 Acceptance Criteria Table 1. Floor surfaces to be coated shall be tested in accordance with ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride or as required by the coating manufacturer. Moisture vapor transmission shall not exceed three pounds per 1,000 square feet in a 24-hour period or less if specified by Coating Manufacturer. Vertical and horizontal overhead surfaces shall be tested in accordance with ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete using in situ Probes (relative humidity shall not exceed 80% or as required by the coating manufacturer) or with ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Test Method (test results shall be no moisture present). Engineer or Coating Manufacturer Representative shall specify all test locations. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer.
- C. Concrete and spall repair materials shall be cured in accordance with concrete and spall repair materials manufacturer's printed cure time prior to coating with epoxy coatings.
- D. Test surfaces to ensure they are within requirements of the manufacturer. Do not begin coating work until moisture is within manufacturer's recommended range. Any leaks shall be repaired as all surfaces shall be free of visible moisture and floating water.
- E. All surface preparation of concrete shall be in accordance with NACE 6/SSPC-SP-13 Joint Surface Preparation Standards and ICRI Technical Guidelines. Surface preparation of concrete shall be performed by a method in accordance with ICRI Technical Guidelines to obtain a minimum ICRI-CSP 5 surface profile or profile as specified by the coating manufacturer. Remove all laitance, weak concrete, dirt, and other contaminants. Remove all fins, protrusions, and similar imperfections to allow a uniform surface after surface preparation. Under no circumstance shall surface preparation be less than manufacturer's recommendation to provide the best possible installation. Following completion of surface preparation, substrates to be coated shall be evaluated by both manufacturer's representative and Engineer based on ICRI Concrete Surface Profile

Chips for concrete surfaces and SSPC Vis Guides for metal surfaces prior to application of coatings. In addition, moisture levels of concrete shall be tested and documented and within acceptable ranges prior to application of coating.

- F. All surface preparation of metal surfaces to receive MIC Coating shall be in accordance with SSPC-SP-5/NACE 1, White Metal Blast Cleaning with a 3.0 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing. All welds shall be prepared to a minimum NACE weld preparation level "C" per NACE Standard SP0178 prior to blast cleaning.
- G. Bugholes, depressions, and irregularities in surfaces with any dimension greater than 0.0625 inch shall be filled with epoxy filler recommended by manufacturer.
- H. Apply epoxy filler to all inside corners of areas to be coated with a margin trowel to form a continuous 45-degree cant cove across corners with a minimum dimension of 1.5-inch. Roughen or prepare cured epoxy filler as recommended by coating manufacturer for proper coating adhesion.
- I. To ease coating around outside corners, provide 3/4-inch chamfered edges on all new concrete outside corners and grind existing concrete outside corners to a minimum radius of 3/4-inch.
- J. Unless recommended otherwise by the coating manufacturer, provide 1/4" deep by 1/4" wide tool cut terminations at 1-inch maximum from all coating edges for anchorage. Provide terminations around all equipment, piping, openings, gates, top and bottom of walls, stop locations of each day's work and overlap onto previously completed work. Transition coating 3-inches onto interior lining of piping except where coating compatibility concerns are noted by coating manufacturer.
- K. All equipment grouting shall be installed and cured prior to starting coating work. Coating shall be applied over grout up to the edges of all equipment, gates and uninterrupted piping unless specifically noted otherwise.
- L. Where the surface deterioration is less than or equal to 1/2-inch (as measured from the final finished surface to the prepared surface to be repaired) skim coats of epoxy modified cementitious mortar shall be applied to restore and smooth surface irregularities to the final finished surface. Epoxy modified mortar system shall be manufactured by same manufacturer of MIC Coating System.
- M. Where the surface deterioration is greater than 1/2 inch the surface shall be repaired to final finished surface using Spall Repair Patching Material, in accordance with Section 03 01 30 – Concrete Repairs. Surface material shall be applied in strict accordance with manufacturer's printed instructions and recommendations. Materials shall be cured a minimum of 10-days or as recommended by the repair material manufacturer for the site conditions. Manufacturer of MIC Coating System shall confirm proposed spall repair patching material is compatible with MIC Coating System.

- N. Where manufacturer requires additional surface preparation, to provide best possible installation, additional requirements shall be performed.
- O. Provided written certification on the coating manufacturer's letterhead, signed by an officer of the company that the surface preparation meets the requirements of the coating manufacturer.
- P. Where coating will be applied across non-moving concrete construction or control joints, joints shall be cleaned with a grinder or hand tools to a width suitable for filler material and then filled with a suitable rigid or semi-rigid joint filler prior to coating application. Joint filler product shall be compatible with coating system and as recommended by coating manufacturer.
- Q. Where coating will be applied across concrete expansion joints that have the potential to crack, coating shall be terminated on both sides of the joint with a proper termination as recommended by coating manufacturer. After coating application and curing, a closed cell polyethylene backer rod shall be installed at a depth of half the joint width and a continuous joint sealant shall be applied to the joint. Joint sealant shall be compatible with coating as recommended by the coating manufacturer and shall be rated for the intended service per Section 07 90 00 – Joint Fillers, Sealants and Caulking.

### **3.03 PRIMER APPLICATION**

- A. Apply tolerant primer at 10 mils or as recommended by manufacturer to achieve superior performance. Test moisture and pH levels of concrete and document. Apply primer when surface is within acceptable ranges prior to application of primer.

### **3.04 MIC COATING APPLICATION**

- A. All methods, procedures of mixing, application and curing of the coating material shall be accomplished in strict accordance with manufacturer's printed instructions and recommendations. Thinning of coating material is prohibited unless written manufacturer approval with project specific directions is provided and approved by Engineer.
- B. Apply MIC Coating in a minimum of two coats in addition to primer and filler. Apply MIC coating in two (2) coats of 50 to 60 mils each for a total DFT of 100 to 120 mils in strict accordance with manufacturer's printed instructions and recommendations.
- C. Application shall be by certified and experienced personnel only. Application of coating systems shall take place when the temperature of the concrete is stable or falling to ensure a minimal amount of out gassing by concrete. Use dehumidification units, fans or other means to provide an adequate environment for application and cure when the environment is not adequate for application or cure.
- D. Application shall produce at a minimum a totally bonded coating, corrosion proof, free of blisters, pinholes and any and all blemishes that may be precursors to failure. Promptly

correct or remove and repair areas that fail visual inspection or testing. Recoat time between coats shall be documented and shall not exceed manufacturer's requirements. Where recoat times are exceeded the coating shall be prepared in strict accordance with manufacturer's recommendations including scarification to provide sufficient profile.

### **3.05 FIELD TESTING AND ACCEPTANCE OF MIC COATING**

- A. Field acceptance of the MIC coating system shall be based on the Engineer's evaluation of the appropriate installation of each coat per field inspections, on observation of the measurements of the wet film thickness, and on the observation of high voltage spark testing and adhesion testing conducted on the cured liner.
- B. Pre-application testing shall be conducted by applying the MIC Coating at 20 mil thickness over a 5 square foot area where directed to demonstrate the coating application to the inspector(s).
- C. During application of each layer of the MIC coating, the Contractor shall measure the thickness and uniformity of the coating by the use of a wet film thickness gage meeting the requirements of ASTM D4414. The wet film thickness shall be tested continuously for the Contractor's own use. At least three such tests will be observed by the Engineer or Owner for each coat in each 500 square feet.
- D. The MIC coating shall provide a continuous monolithic surfacing with uniform thickness throughout and be free of pinholes, slumps and drips.
- E. All surfaces shall be inspected via high voltage spark testing when all coating work is complete and the coating is hard to the touch.
  - 1. The structure environment shall be properly vented prior to testing to ensure hazardous conditions do not exist.
  - 2. High voltage spark testing shall be performed in accordance with ASTM D4787. The spark testing equipment shall be initially set at 100 volts per 1 mil of applied film thickness of the coating and then adjusted as necessary per ASTM D 4787.
  - 3. All detected holidays shall be marked and the area of the liner shall be repaired. The surface area around the coating shall first be abraded using an appropriate grit paper or other hand abrasion tool. After abrading and cleaning the area, the area shall be patched by hand application of the coating material. All repair procedures shall follow manufacturer's recommended procedures.
- F. The pull-off strength (adhesion) of the liner shall be tested using any one of the five Test Methods (B, C, D, E, or F) described in ASTM D-4541 for coatings on metal substrates and ASTM D-7234 for coatings on concrete. The Contractor shall propose the method and equipment to be used in the tests. The liner adhesion shall be tested in one area for each structure or each 1000 square feet of coated area. At least three replicate pull-off

tests shall be performed for each area. The Contractor shall also submit his proposed method for reinstatement of the area of the coating affected by the test. Repair of test areas shall be made by the Contractor at no additional cost to the Owner.

- G. There shall be no groundwater infiltration or other leakage through the structure walls after coating. If leakage is found, it shall be eliminated with an appropriate method as recommended by the coating manufacturer and approved by the Engineer at no additional cost to the Owner.
- H. All pipe connections shall be open and clear.
- I. There shall be no cracks, voids, pinholes, uncured spots, dry spots, lifts, delaminations or other type defects in the lining.
- J. If any defective coating is discovered after it has been installed, it shall be repaired or replaced in a satisfactory manner within 72 hours and at no additional cost to the Owner. This requirement shall apply for the entire guarantee period.

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**SECTION 26 05 00**  
**BASIC ELECTRICAL REQUIREMENTS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.
  
- B. Reference Section 40 61 13 – Process Control System General Provisions and General Requirements for scope of work details as they relate to the Division 40 Subcontractor.
  
- C. The electrical scope of work for this project primarily includes, but is not limited to, the following:
  - 1. Furnish and install low voltage motor control equipment including reduced voltage motor starters and variable frequency drives.
  - 2. Furnish and install power panelboards, lighting panelboards, dry-type transformers, and other low voltage electrical power distribution equipment.
  - 3. Furnish and install all aboveground raceway systems including conduit, fittings, boxes, supports, and other pertinent components.
  - 4. Furnish and install all underground raceway systems including conduit, fittings, manholes, handholes and other pertinent components.
  - 5. Furnish and install all wire and cable resulting in a complete and operable electrical system.
  - 6. Furnish and install new lighting systems and wiring devices.
  - 7. Other electrical work as specified herein and indicated on the Drawings.

- D. All material and equipment must be the product of an established, reputable, and approved manufacturer; must be new and of first class construction; must be designed and guaranteed to perform the service required; and must bear the label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the Engineer.
- E. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner.
- F. Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer. The Contractor's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.
- G. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.
- H. All electrical components and systems, including electrical equipment foundations, shall be designed to resist operational forces as well as lateral sway and axial motion from seismic and thermal forces. Seismic support design shall be in accordance with Section 01 73 23 – Seismic Anchorage and Bracing.

## **1.02 EQUIPMENT LOCATION**

- A. The Drawings show the general location of feeders, transformers, outlets, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The Contractor shall carefully investigate the structural and finish conditions affecting the work and shall arrange such work accordingly; furnishing such fittings, junction boxes, and accessories as may be required to meet such conditions. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to ensure that proposed equipment will fit properly in spaces indicated.
- B. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The Contractor shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings.

### 1.03 LOCAL CONDITIONS

- A. The Contractor shall examine the site and become familiar with conditions affecting the work. The Contractor shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.
- B. The Contractor is responsible for coordinating all electric utility equipment installations with the serving electric utility. The Contractor shall furnish and install all electric utility equipment required by the electric utility to be installed by the Contractor whether specifically shown on the Drawings or not.
- C. The Contractor shall furnish and install the following electrical utility equipment as a minimum:
  - 1. Secondary ductbank and manholes
  - 2. Metering equipment cabinets and/or bases
  - 3. Conduit and wire required from metering cabinet to metering current transformers and potential transformers.
  - 4. Secondary conductors
  - 5. Secondary terminations
- D. The electric utility will furnish and install the following equipment:
  - 1. Primary conductors and terminations
  - 2. Utility Transformer
  - 3. Power pole
- E. The Contractor is responsible for ensuring all electric utility equipment and construction installed by the Contractor is furnished and installed in accordance with the electric utility's design specifications and requirements. The Contractor is fully responsible for coordinating all required work with the electric utility. Any additional required electric utility construction or equipment not specified herein or shown on the Drawings shall be supplied by the Contractor at no additional cost to the Owner.

F. The contact person at the serving electrical utility is:

Anthony Lepoma – Key Account Manager  
Georgia Power Company  
BIN 79610  
119 Smith Street  
Jonesboro, GA 30236  
(706) 603-5352  
[aslepoma@southernco.com](mailto:aslepoma@southernco.com)

#### **1.04 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures and the requirements of the individual specification sections, the Contractor shall obtain from the equipment manufacturer and submit the following:
1. Shop Drawings
  2. Operation and Maintenance Manuals
  3. Spare Parts List
  4. Proposed Testing Methods and Reports of Certified Shop Tests
  5. Reports of Certified Field Tests
  6. Manufacturer's Representative's Certification
- B. Submittals shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements.
- C. Submittals will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which the Contractor has provided no information.
- D. Some individual electrical specification sections may require a Compliance, Deviations, and Exceptions (CD&E) letter to be submitted. If the CD&E letter is required and shop drawings are submitted without the letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the

deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

- E. Seismic support design for all nonstructural electrical components (conduit, raceways, freestanding equipment, etc.) shall be in accordance with all applicable federal, state and local building code requirements and Section 01 73 23 – Seismic Anchorage and Bracing.

## **1.05 APPLICABLE CODES AND REQUIREMENTS**

### **A. Conformance**

1. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the following:
  - a. Insurance Rating Organization having jurisdiction
  - b. The serving electrical utility company
  - c. The currently adopted edition of the National Electrical Code (NEC)
  - d. The National Electric Manufacturers Association (NEMA)
  - e. The Institute of Electrical and Electronic Engineers (IEEE)
  - f. The Insulated Cable Engineers Association (ICEA)
  - g. The American Society of Testing Materials (ASTM)
  - h. The American National Standards Institute (ANSI)
  - i. The requirements of the Occupational Safety Hazards Act (OSHA)
  - j. The National Electrical Contractors Association (NECA) Standard of Installation
  - k. National Fire Protection Association (NFPA)
  - l. International Electrical Testing Association (NETA)
  - m. All other applicable Federal, State and local laws and/or ordinances.
2. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.

B. Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid. Ignorance of any rule, requirement, or Specification shall not be allowed as an excuse for nonconformity. Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors which may exist in the drawings submitted or in the satisfactory operation of any equipment.

C. Certification

1. Upon completion of the work, the Contractor shall obtain certificate(s) of inspection and approval from the National Board of Fire Underwriters or similar inspection organization having jurisdiction and shall deliver same to the Engineer and the Owner.

**1.06 PERMITS AND INSPECTIONS**

- A. The Contractor shall reference the General Conditions and Section 01 11 00 – Summary of Work.

**1.07 TEMPORARY LIGHTING AND POWER**

- A. The Contractor shall reference the General Conditions and Section 01 51 00 – Temporary Utilities.

**1.08 TESTS**

- A. Upon completion of the installation, the Contractor shall perform tests for operation, load (Phase) balance, overloads, and short circuits. Tests shall be made with and to the satisfaction of the Owner and Engineer.
- B. The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Owner. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five (5) times.
- C. Refer to each individual specification section for detailed test requirements.
- D. The Contractor shall complete the installation and field testing of the electrical installation at least two (2) weeks prior to the start-up and testing of all other equipment.

During the period between the completion of electrical installation and the start-up and testing of all other equipment, the Contractor shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.

- E. Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, personnel and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any electrical equipment required as part of the field tests of other systems.

#### **1.09 INFRARED INSPECTION**

- A. Just prior to the final acceptance of a piece of equipment, the Contractor shall perform an infrared inspection to locate and correct all heating problems associated with electrical equipment terminations.
- B. The infrared inspection shall apply to all new equipment and existing equipment that is in any way modified under this Contract. All heating problems detected with new equipment furnished and installed under the Scope of this Contract shall be corrected by the Contractor. All problems detected with portions of existing equipment modified under this Contract shall also be corrected by the Contractor.
- C. Any issues detected with portions of existing equipment that were not modified under this Contract are not the responsibility of the Contractor. Despite the Contractor not being held responsible for these problems, the Contractor shall report them to the Owner and Engineer immediately for resolution.
- D. The infrared inspection report shall include both digital and IR pictures positioned side by side. Both the digital and IR pictures shall be clear and high quality. Fuzzy, grainy, or poorly illuminated pictures are not acceptable. The IR picture shall be provided with a temperature scale beside it, and an indication of the hot spot temperature in each picture. Reports shall be furnished in a 3-ring binder, with all pages printed in full color, with equipment assemblies separated by tabs.

#### **1.10 PROTECTIVE DEVICE SETTING AND TESTING**

- A. The Contractor shall provide the services of a field services organization to adjust, set, calibrate and test all protective devices in the electrical system. The organization shall be a subsidiary of or have a franchise service agreement with the electrical equipment manufacturer. The qualifications of the organization and resumes of the technicians as well as all data forms to be used for the field testing shall be submitted.
- B. All protective devices in the electrical equipment shall be set, adjusted, calibrated and tested in accordance with the manufacturers' recommendations, the coordination study, and best industry practice.

- C. Proper operation of all equipment associated with the device under test and its compartment shall be verified, as well as complete resistance, continuity and polarity tests of power, protective and metering circuits. Any minor adjustments, repairs and/or lubrication necessary to achieve proper operation shall be considered part of this Contract.
- D. All solid state trip devices shall be checked and tested for setting and operation using manufacturers recommended test devices and procedures.
- E. Circuit breakers and/or contactors associated with the above devices shall be tested for trip and close functions with their protective device.
- F. When completed, the Contractor shall provide a comprehensive report for all equipment tested indicating condition, readings, faults and/or deficiencies in same. Inoperative or defective equipment shall be brought immediately to the attention of the Engineer.
- G. Prior to placing any equipment in service, correct operation of all protective devices associated with this equipment shall be demonstrated by field testing under simulated load conditions.

#### **1.11 POWER SYSTEM STUDIES**

- A. The Contractor shall provide Power System studies performed by a Professional Engineer registered with the state of Georgia to the firm providing the protective device setting and testing services. The Contractor shall notify the Engineer six (6) weeks in advance of the scheduled date for the protective device setting and testing.
- B. Data Collection for the Studies:
  - 1. The Contractor shall provide the required data for preparation of the studies.
  - 2. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.
- C. Protective Device Coordination Study:
  - 1. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage circuit breaker trip characteristics and settings.
  - 2. The coordination study shall include all low voltage classes of equipment from the utility company service protective devices down to and including the feeder circuit breakers of motor control center. The phase and ground overcurrent protection shall be included as well as settings of all other adjustable protective devices.



3. The time-current characteristics of the specified protective devices shall be drawn on 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 and fuses. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits and significant symmetrical and asymmetrical fault currents. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.
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 and connections, manufacturer and type, range of adjustment and recommended settings. A tabulation of the recommended power fuse selection shall be provided for the medium voltage fuses where applied in the system. Any discrepancies, problem areas, or inadequacies shall be promptly brought to the attention of the Engineer.

D. Arc Flash Hazard Analysis:

1. An Arc Flash Hazard Analysis shall be performed with the aid of a digital computer program in accordance with IEEE Std. 1584, "IEEE Guide For Performing Arc Flash Hazard Calculations", NFPA 70E, and OSHA 29-CFR, Part 1910 Subpart S.
2. Arc Flash Warning Labels and Bus Detail Sheets shall be produced for each bus affected by the electrical modifications in this project. Labels shall be printed in color on adhesive backed labels. Labels shall be attached to the doors of the equipment. Each label and detail sheet shall list the following:
  - a. Bus name.
  - b. System operating voltage.
  - c. Date of issue.
  - d. Flash hazard protection boundary.
  - e. Limited approach boundary.
  - f. Restricted boundary.
  - g. Prohibited boundary.

- h. Incident energy level.
  - i. Required personal protective equipment class.
  - j. In addition, each Bus Detail Sheet shall list the Upstream Protective Devices Names, Type and Settings.
3. Arc Flash Evaluation Summary Sheets shall be produced. Summary sheets shall list the following:
- a. Bus name.
  - b. Upstream protective device name, type and settings.
  - c. Bus line-to-line voltage.
  - d. Bus bolted fault.
  - e. Protective device bolted fault current.
  - f. Arcing fault current.
  - g. Protective device trip / delay time.
  - h. Breaker opening time.
  - i. Solidly grounded column.
  - j. Equipment type.
  - k. Gap.
  - l. Arc flash boundary.
  - m. Working distance.
  - n. Incident energy.
  - o. Required personal protective equipment class.
4. Analyze the short circuit, protective device coordination, and arc flash calculations and highlight any equipment that is determined to be underrated or causes an abnormally high incident energy calculation. Propose approaches to reduce the energy levels. Proposed major corrective modifications will be taken under advisement by the Engineer and the Contractor will be given further instructions.

E. Study Report:

1. The results of the power system studies shall be summarized in a report. The report shall be submitted to the Engineer.
2. The report shall include the following sections:
  - a. Description, purpose, basis and scope of the study and a detailed single line diagram with "nodes" cross-referenced to the calculated values tabulated in the study report of that portion of the power system which is included within the scope of the study.
  - b. Tabulations of circuit breaker, fuse and other protective device 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 calculations including a definition of terms and guide for interpretation of computer printout.
3. Prior to commencing the work, the preparer the studies shall meet with the testing firm that will do the relay field testing and the Owner's representative at the site for a walk through of the facility to insure that existing conditions are taken into account.
4. The study shall include a detailed explanation of all software programs and procedures used to arrive at the calculated values, settings, and drawings (e.g. single line diagrams) showing fault valves at all busses.

**1.12 SCHEDULES AND FACILITY OPERATIONS**

- A. Since the equipment testing required herein shall require that certain pieces of equipment be taken out of service, all testing procedures and schedules must be submitted to the Engineer for review and approval one (1) month prior to any work beginning. When testing has been scheduled, the Engineer must be notified 48 hours prior to any work to allow time for load switching and/or alternation of equipment. In addition, all testing that requires temporary shutdown of facility equipment must be coordinated with the Owner/Engineer so as not to affect proper facility operations.
- B. At the end of the workday, all equipment shall be back in place and ready for immediate use should a facility emergency arise. In addition, should an emergency condition occur during testing, at the request of the Owner, the equipment shall be placed back in service immediately and turned over to Owner personnel.

- C. In the event of accidental shutdown of Owner equipment, the Contractor shall notify Owner personnel immediately to allow for an orderly restart of affected equipment.
- D. Maintaining the operation of these facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01 14 00 – Coordination with Owner’s Operations for construction sequencing and specific operational constraint information.

### **1.13 MATERIALS HANDLING**

- A. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material will be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer. If space heaters are provided in a piece of electrical equipment, they shall be temporarily connected to a power source during storage. The Contractor shall store equipment and materials in accordance with Section 01 55 00 – Contractor Access and Parking.

### **1.14 WARRANTIES**

- A. Unless otherwise specified in an individual specification section, all electrical equipment and electrical construction materials shall be provided with a warranty in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and the General Conditions.

### **1.15 TRAINING**

- A. Unless otherwise specified in an individual specification section, all training for electrical equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.

## **PART 2 – PRODUCTS**

### **2.01 PRODUCT REQUIREMENTS**

- A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical

Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

- B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.
- C. All equipment and materials shall be new, unless indicated or specified otherwise.
- D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that are provided under this Contract meet the requirements of Underwriters Laboratories, Inc., in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming to this requirement.

## **2.02 SUBSTITUTIONS**

- A. Unless specifically noted otherwise, any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contractor, in such cases may use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

## **2.03 CONCRETE**

- A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A unless otherwise specified. Concrete and reinforcing steel shall meet the appropriate requirements of Division 3 of the Specifications.
- B. The Contractor shall provide concrete equipment pads for all free-standing electrical apparatus and equipment located on new or existing floors or slabs. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings and shall conform to standard detail for equipment pads shown on the Contract Drawings. Equipment pads shall not have more than 3" excess concrete beyond the edges of the equipment.

## **2.04 RUBBER INSULATING MATTING**

- A. Rubber insulating matting shall be furnished and installed on the floor and in front of each piece of electrical equipment that is located indoors and installed under this Contract. Rubber insulating matting shall not be installed outdoors. The mat shall be long enough to cover the full length of the equipment. The mat shall be ¼-inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The matting shall meet OSHA requirements and the requirements of ASTM D-178 for Type 2, Class 2 insulating matting. Matting shall be 36 inches wide, minimum.

However, matting width shall be no less than the NEC working clearance for the equipment with which it is associated.

B. Matting shall be provided for the following equipment:

1. PLC/RTU Enclosures
2. Indoor Control Panels
3. Motor Control Centers
4. Panelboards
5. Automatic Transfer Switches

### **PART 3 – EXECUTION**

#### **3.01 CUTTING AND PATCHING**

A. Coordination

1. The Work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

B. Damage

1. The Contractor shall perform all chasing, channeling, drilling and patching necessary to the proper execution of this Contract. Any damage to the building, structure, or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at the Contractor's expense.

C. Existing Equipment

1. Provide a suitable cover or plug for openings created in existing equipment as the result of work under this Contract. For example, provide round plugs in equipment enclosures where the removal of a conduit creates a hole in the enclosure. Covers and plugs shall maintain the NEMA rating of the equipment enclosure. Covers and plugs shall be watertight when installed in equipment located outdoors.

### **3.02 EXCAVATION AND BACKFILLING**

- A. The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable requirements of Division 31.

### **3.03 CORROSION PROTECTION**

- A. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

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**SECTION 26 05 19**  
**LOW VOLTAGE CONDUCTORS AND CABLES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, all low voltage wire and cable indicated on the Drawings and as specified herein and/or required for proper operation. The work of connecting cables to equipment and devices shall be considered a part of this Section. All appurtenances required for the installation of wire and cable systems shall be furnished and installed by the Contractor.
- B. The scope of this Section does not include internal wiring factory installed by electrical equipment manufacturers.
- C. Reference Section 26 05 00 – Basic Electrical Requirements and Section 26 05 33.16 – Boxes for Electrical Systems.

**1.02 CODES AND STANDARDS**

- A. Low voltage wire, cable, and appurtenances shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. Underwriters Laboratories (UL)
    - a. UL 13 – Standard for Power-Limited Circuit Cables
    - b. UL 44 – Thermoset-Insulated Wires and Cables
    - c. UL 83 – Thermoplastic-Insulated Wires and Cables
    - d. UL 1277 – Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
    - e. UL 1581 – Reference Standard for Electrical Wires, Cables, and Flexible Cords
    - f. UL 1685 – Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
    - g. UL 2250 – Standard for Instrumentation Tray Cable
    - h. UL 2556 – Wire and Cable Test Methods
  - 2. American Society for Testing and Materials (ASTM)

- a. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire
  - b. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
  - c. ASTM B33 – Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
  - d. ASTM D69 – Standard Test Methods for Friction Tapes
  - e. ASTM D4388 – Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes
3. Insulated Cable Engineers Association (ICEA)
    - a. ICEA S-58-679 – Standard for Control, Instrumentation and Thermocouple Extension Conductor Identification
    - b. ICEA T-29-250 – Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 210,000 B.T.U./Hour
  4. Institute of Electrical and Electronics Engineers (IEEE)
    - a. IEEE 1202 – Standard for Flame Testing of Cables

### **1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the wire and cable manufacturer and submit the following:
  1. Shop Drawings
  2. Reports of Field Tests
- B. Each submittal shall be identified by the applicable specification section.

### **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:

1. Product data sheets for wire and cable, terminations, and pulling lubricant.
  2. Cable pulling calculations (if required).
  3. Wiring identification methods and materials.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

### **1.05 CABLE PULLING CALCULATIONS (NOT USED)**

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years. Wire and cable shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings. Only one (1) manufacturer for each wire and cable type shall be permitted.

### **2.02 POWER AND CONTROL WIRE AND CABLE**

- A. Power wire for all loads and control wire shall consist of insulated copper conductors with a nylon (or equivalent) outer jacket. Conductor insulation shall be rated 90°C for dry locations, 75°C for wet locations, and 600V. Insulated conductors shall be UL 83 Listed as NEC Type THHN/THWN.
- B. Unless specified otherwise herein, conductors shall be stranded copper per ASTM B-8 and B-3, with Class B or C stranding contingent upon the size.
- C. Power conductor size shall be no smaller than No. 12 AWG and Control conductor size shall be no smaller than No. 14 AWG.
- D. Multi-conductor cable assemblies shall include a grounding conductor and an overall PVC jacket. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Multi-conductor cable assemblies shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).
- E. Power wire and cable shall be as manufactured by the Okonite Company, the Southwire Company, General Cable, Encore Wire, or equal.

### **2.03 INSTRUMENTATION CABLE**

- A. For single-analog signal applications, instrumentation cable shall consist of a single, twisted pair or triad of individually insulated and jacketed copper conductors with an overall cable shield and jacket. Conductor insulation shall be rated 90°C in both wet and dry locations, and 600V. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Cable shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).
- B. For multiple-analog signal applications, instrumentation cable shall consist of multiple, twisted pairs or triads (i.e. groups) of individually insulated and jacketed copper conductors with individual pair/triad shields (i.e. group shields) and an overall cable shield and jacket. Conductor insulation shall be rated 90°C in both wet and dry locations, and 600V. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Cable shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).
- C. Cable and group shields shall consist of overlapped aluminum/polyester tape/foil providing 100% coverage. Instrumentation cables shall include an overall copper shield drain wire. Cables containing multiple twisted pairs or triads shall also include group shield drain wires.
- D. Conductors, including drain wires, shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM B-8, with Class B stranding unless otherwise specified.
- E. Instrumentation signal conductor size shall be no smaller than No. 16 AWG.
- F. Instrumentation cable shall be Okoseal-N Type P-OS (for single pair or triad applications) or Okoseal-N Type SP-OS (for multiple pair or triad applications) as manufactured by the Okonite Company, Belden equivalent, Southwire Company equivalent, or equal.

## **2.04 SHIELDED VFD CABLE (NOT USED)**

## **2.05 CONDUCTOR IDENTIFICATION**

- A. Conductors shall be identified using a color-coding method. Color coding for individual power, control, lighting, and receptacle conductors shall be as follows:
  - 1. 480/277V AC Power
    - a. Phase A – BROWN
    - b. Phase B – ORANGE
    - c. Phase C – YELLOW
    - d. Neutral – GREY

2. 120/208V or 120/240V AC Power
    - a. Phase A – BLACK
    - b. Phase B – RED
    - c. Phase C – BLUE
    - d. Neutral – WHITE
  3. DC Power
    - a. Positive Lead – RED
    - b. Negative Lead - BLACK
  4. DC Control
    - a. All wiring – BLUE
  5. 120 VAC Control
    - a. 120 VAC control wire shall be RED except for a wire entering a motor control center compartment, motor controller, or control panel which is an interlock. This interlock conductor shall be color coded YELLOW. For the purposes of this Section, an interlock is defined as any wiring that brings voltage into the above-mentioned equipment from a source outside that equipment.
  6. 24 VAC Control
    - a. All wiring - ORANGE
  7. Equipment Grounding Conductor
    - a. All wiring - GREEN
- B. Individual conductors No. 2 AWG and smaller shall have factory color coded insulation. It is acceptable for individual conductors larger than No.2 AWG to be provided with factory color coded insulation as well, but it is not required. Individual conductors larger than No.2 AWG that are not provided with factory color coded insulation shall be identified by the use of colored tape in accordance with the requirements listed in Part 3 herein. Insulation colors and tape colors shall be in accordance with the color-coding requirements listed above.
- C. Conductors that are part of multi-conductor cable assemblies shall have black insulation. The conductor number shall be printed on each conductor's insulation in accordance with ICEA S-58-679, Method 4. Each conductor No.2 AWG and smaller within the cable assembly shall also be identified with a heat shrink tag with color coded background.

Each conductor larger than No.2 AWG within the cable assembly shall also be identified by the use of colored tape. Heat shrink tags and colored tape shall be in accordance with the requirements listed in Part 3 herein. Tape color and heat shrink tag background color shall be in accordance with the color-coding requirements listed above.

## **2.06 CABLE PULLING LUBRICANTS**

- A. Cable pulling lubricants shall be non-hardening type and approved for use on the type of cable installed. Lubricant shall be Yellow #77 Plus by Ideal, Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equal.

## **PART 3 – EXECUTION**

### **3.01 WIRE AND CABLE INSTALLATION**

#### **A. General**

1. Wire and Cable shall be installed as specified herein and indicated on the Drawings. Unless specifically indicated otherwise on the Drawings, wire and cable shall be installed in separate raceways according to wiring type. For example, power wiring shall not be combined with control wiring, and control wiring shall not be combined with instrumentation wiring.
2. Wire shall be furnished and installed as single conductor cables, with limited exceptions. Multi-conductor cable assemblies shall only be installed where indicated on the Drawings, required by the NEC, or after obtaining written permission from the Engineer.
3. Where instrumentation cables are installed in control panels, motor controllers, and other locations, the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.
4. Instrumentation cable shielding shall be continuous and shall be grounded at one point only.

#### **B. Splices**

1. Splices shall not be allowed in power or control wire and cable unless approved in writing by the Engineer. If unique field conditions exist or pulling calculations indicate that splices may be required, the Contractor shall submit a detailed request indicating why splices are required to the Engineer. The Engineer shall be under no obligation to grant such request.

2. Splicing materials shall be barrel type butt splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equal. The use of screw-on wire connectors (wire nuts) shall only be permitted for lighting and receptacle circuits.
3. No splicing of instrumentation cable is permitted.

#### C. Wire and Cable Sizes

1. The sizes of wire and cable shall be as indicated on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop measured from source to load does not exceed 2-1/2%.

#### D. Additional Conductor Identification

1. In addition to the color-coding identification requirements specified in Part 2 herein, individual conductors shall be provided with heat shrinkable identification tags. Identification tags for individual conductors shall have a white background where the conductor insulation is colored. Identification tags for individual conductors shall have a colored background where the conductor insulation is black. Background color shall match that of the taping provided on the individual black conductors.
2. Multi-conductor cables shall be provided with heat shrinkable identification tags in accordance with Part 2 herein.
3. All wiring shall be identified at each point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where a termination is made. The Contractor shall meet with the Owner and Engineer to come to an agreement regarding a wire identification system prior to installation of any wiring. Wire numbers shall not be duplicated. The wire identification schemes below are a starting point for the discussions with the Owner.
  - a. Label analog cables with a marker that describes INSTRUMENT TAG / DESTINATION PANEL. Label each conductor in the cable with INSTRUMENT TERMINAL No. / DESTINATION TERMINAL No.
  - b. Label digital communication cables and fiber optic cables with a TO/FROM marker.
  - c. Label the conductors of discrete signals from instruments and devices with the signal's LOOP No. / DESTINATION TERMINAL No.
  - d. Label the conductors of power feeders and branch circuits with the equipment designation of the source equipment plus a suffix that includes

the bucket number, the compartment number, or the panelboard circuit identifier.

4. Wire identification shall be by means of a heat shrinkable sleeve with appropriately colored background and black text. Wire sizes #14 AWG through #10 AWG shall have a minimum text size of 7 points. Wire sizes #8 AWG and larger shall have a minimum text size of 10 points. Sleeves shall be of appropriate length to fit the required text. The use of handwritten text for wire identification shall not be permitted.
5. Sleeves shall be suitable for the size of wire on which they are installed. Sleeves shall not be heat-shrunk onto control cables. Tags shall remain loose on cable to promote easier identification. For all other applications, sleeves shall be tightly affixed to the wire and shall not move. Sleeves shall be heat shrunk onto wiring with a heat gun approved for the application. Sleeves shall not be heated by any means which employs the use of an open flame. The Contractor shall take special care to ensure that the wiring insulation is not damaged during the heating process.
6. Sleeves shall be installed prior to the completion of the wiring terminations and shall be oriented so that they can be easily read.
7. Sleeves shall be polyolefin as manufactured by Brady, Seton, Panduit, or equal.
8. Wire identification in manholes, handholes, pull boxes, and other accessible components in the raceway system where the wiring is continuous (no terminations are made) shall be accomplished by means of a tag installed around the bundled group of individual conductors or around the outer conductor jacket of a multi-conductor cable. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all of the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that particular conduit number in the conduit and wire schedule. Minimum text size shall be 10 point. The tag shall be affixed to the wire bundle by the use of nylon wire ties and shall be made of polyethylene as manufactured by Brady, Seton, Panduit, or equal.
9. Where colored tape is used to identify cables, it shall be wrapped around the cable with a 25% overlap and shall cover at least 2 inches of the cable.

#### E. Wiring Supplies

1. Rubber insulating tape shall be in accordance with ASTM D4388. Friction tape shall be in accordance with ASTM D69.

#### F. Training of Cable in Manholes, Handholes, and Vaults



1. The Contractor shall furnish all labor and material required to train cables around cable vaults, manholes, and handholes. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. The training shall be done in such a manner as to minimize chaffing.
2. Instrumentation cable shall be racked and bundled separate from AC wiring to maintain the required separation as follows:
  - a. 18 inches for 480/277 VAC wiring
  - b. 12 inches for 208/120 VAC wiring
  - c. 6 inches for 24 VAC wiring

#### G. Conductor Terminations

1. Where wires are terminated at equipment which requires lugs, connections shall be made by solderless mechanical lug, crimp type ferrule, or irreversible compression type lugs. Reference individual equipment specification sections as applicable for additional termination requirements.
2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make terminations impractical due to the size of the field wiring, the Contractor shall terminate field wiring in an adjacent junction box per the requirements of Section 26 05 33.16 – Boxes for Electrical Systems, complete with terminal strips. Contractor shall install the smaller wiring from the device to the junction box in a conduit, using the terminal strip as the means for joining the two different wire sizes. Splicing of wires in lieu of using terminal strips is not acceptable.
3. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.
4. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or equal.
5. All spare conductors shall be terminated on terminal blocks mounted within equipment or junction boxes. Unless otherwise noted, coiling up of spare conductors within enclosure is not acceptable.

#### H. Pulling Temperature

1. Cable shall not be installed when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less within a three (3) day period prior to pulling, the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the work day for which the cable is removed from the protected storage. Any cable reels with wire remaining on them shall be returned to storage at the completion of the workday.

### **3.02 FIBER OPTIC CABLE INSTALLATION**

- A. The Contractor shall install the fiber optic cable furnished by the General Contractor and/or the Instrumentation and Control Subcontractor. The cable shall be installed in its respective raceway system(s) as specified herein, indicated on the Drawings, and in accordance with the cable manufacturer's instructions. Reference Division 40 for additional information regarding the fiber optic cable.

### **3.03 TESTING**

- A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Shop Test

- a. Wires and cables shall be tested in accordance with the applicable ICEA Standards. Wire and cable shall be physically and electrically tested in accordance with the manufacturer's standards.

2. Field Tests

- a. After installation, all wires and cables shall be tested for continuity. Testing for continuity shall be "test light" or "buzzer" style.
- b. After installation, some wires and cables shall be tested for insulation levels. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:
  - 1) For #8 AWG and larger 600V wire and cable, apply 1,000 VDC from a Megohmmeter for one (1) minute. Resistance shall be no less than 100 Megohms. Insulation testing is not required for power and control cables smaller than #8 AWG.
  - 2) Instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter or approved equal. The resistance value shall be 200 Megohms or greater.

- B. Wires and cables shall be tested after required terminations are made, but before being connected to any equipment.
- C. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner. All conductors of a multi-phase circuit shall be replaced if one conductor fails the required testing. If part of a multi-set (parallel conductors per phase) circuit fails testing, only the set containing failure shall be replaced.
- D. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment. Test reports shall be submitted to the Engineer.

**Exhibit A**  
**Test Data – Megohms**  
Test No. \_\_\_\_\_

Date:			Company:				
Time:			Location:				
Circuit:	Circuit Length:	Aerial:	Duct:	Buried:	No. of Conductors	Size:	AWG MCM Shield:
Insulation Material:			Insulation Thickness:		Voltage Rating:		Age:
Type: _____ Pothead _____ Terminal					Location:     Indoors _____ Outdoors _____		

Number and Type of Joints:

---

Recent Operating History:

---

Manufacturer:

---

State if Potheads or Terminals were grounded during test:

---

List associated equipment included in test:

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Miscellaneous Information:

**Exhibit A**  
**Test Data – Megohms**  
**Test No. \_\_\_\_\_**

Part Tested:	Test Performed: _____ Hours/Days: _____ After Shutdown: _____
Grounding Time:	Dry Bulb Temperature: _____ Wet Bulb Temperature: _____
Test Voltage:	Equipment Temperature: _____ How Obtained: _____ Relative Humidity: _____ Absolute Humidity: _____ Dew Point: _____

Megohmmeter:    Serial Number: \_\_\_\_\_    Range: \_\_\_\_\_  
                          Voltage: \_\_\_\_\_    Calibration Date: \_\_\_\_\_

Test Connections	To Line	To Line	To Line	Test Connections	To Line	To Line	To Line
	To Earth	To Earth	To Earth		To Earth	To Earth	To Earth
	To Ground	To Ground	To Ground		To Ground	To Ground	To Ground
1/4 Minute				5 Minutes			
1/2 Minute				6 Minutes			
3/4 Minute				7 Minutes			
1 Minute				8 Minutes			
2 Minutes				9 Minutes			
3 Minutes				10 Minutes			
4 Minutes				10/1 Minute Ratio			

Remarks:

**END OF SECTION**

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**SECTION 26 05 26**  
**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered a minimum requirement for compliance with this Specification.
- B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100. Conflicts shall be promptly brought to the attention of the Engineer.
- C. In addition to the NEC requirements, building structural steel columns shall be permanently and effectively grounded:
- D. Reference Section 26 05 00 – Basic Electrical Requirements

**1.02 CODES AND STANDARDS**

- A. Equipment and materials covered under this Section shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. UL 467 – Grounding and Bonding Equipment
  - 2. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
  - 3. IEEE 1100 – Recommended Practice for Power and Grounding Electronic Equipment

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings
  - 2. Reports of certified field tests.
- B. Each submittal shall be identified by the applicable specification section.

## **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
  - 1. Product data sheets.
  - 2. Drawings and written description of how the Contractor intends to furnish and install the grounding system.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

### **2.02 GROUND RODS AND GRID**

- A. Ground rods shall be rolled to a commercially round shape from a welded copper-clad steel manufactured by the molten-welding process or by the electro-formed process (molecularly bonded). They shall have an ultimate tensile strength of 75,000 pounds per square inch (psi) and an elastic limit of 49,000 psi. The rods shall be not less than 3/4 inch in diameter by 10 feet in length; and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of 0.010 inch at any point on the rod. Ground rods shall be UL 467 listed. The ground rods shall be manufactured by Erico Products, Blackburn, or equal.
- B. Except where specifically indicated otherwise, all exposed non current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be grounded.
- C. The ground connection shall be made at the main service equipment and shall be extended to the ground grid surrounding the structure. The ground grid shall also be connected to the point of entrance of the metallic water service. Connection to the water pipe shall be made by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, connection shall be made with the lug bolted to the street side of the flanged connection.



- D. Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

### **2.03 FITTINGS**

- A. Grounding connections to equipment shall be bolted. Cable end connections shall be made by hydraulic crimp or exothermically welded. Split bolt type connectors are not acceptable. Fittings shall be UL 467 listed.

### **2.04 BARE GROUND CABLE**

- A. Bare ground cable shall be soft-drawn, bare copper stranded cable complying with ASTM B8. No. 4/0 AWG minimum size unless otherwise shown or indicated on the Drawings. No. 6 A.W.G., when installed bare, shall be solid.

### **2.05 EQUIPMENT GROUNDING CONDUCTORS**

- A. An insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Insulation shall be of the same type as the ungrounded conductors in the raceway and shall be green in color. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

### **2.06 EQUIPMENT GROUNDS**

- A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.
- B. For all control panels, disconnect switches, and other electrical enclosures, equipment grounds and bonding jumpers shall be terminated individually on a ground bar or mechanical lugs. No wire nuts will be permitted.

### **2.07 CONNECTIONS**

- A. All exothermic welding shall be completed per welding kit manufacturer's instructions. Exothermic welds shall be CadWeld by Erico or ThermoWeld.
- B. Compression connections shall be compress-deforming type equal to Burndy Corp. Hyground Irreversible Compression. Connections shall make single indentations for conductors No. 6 and smaller; double indentations for conductors No. 4 and larger. Compression barrels shall be pre-filled with oxide-inhibiting compound and shall be sealed.

## **2.08 WALL MOUNTED GROUNDING BUSBAR**

- A. All wall mounted grounding busbar shall include busbar, insulators, and mounting brackets provided from the same manufacturer.
- B. Busbar shall be a minimum of ¼" thick, 2" wide, 36" long, tin plated, solid copper bus bar.
- C. Busbar shall be UL listed and predrilled with hole pattern suitable for approved grounding lug connectors.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.
- B. Ground Grid
  - 1. A main ground grid shall be provided for each structure and interconnecting structure grids consisting of driven ground rods as shown on the Drawings.
  - 2. Ground rods shall be driven straight down into the earth, or if objects are encountered, at an angle to avoid the obstruction.
  - 3. The ground rods shall be interconnected by the use of copper cable exothermically welded to the rods. The grounding cables shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtails" shall be connected to the ground grid and shall enter the buildings and structure from the outside and shall be connected to steel structures, and equipment as described in this Section and as required to provide a complete grounding system. The copper pigtails shall be exothermically welded to the ground grid and connected to building reinforcement steel by hydraulic crimp.
  - 4. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.
  - 5. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.

6. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.
7. Buried exothermic welds and ground ring shall not be backfilled until inspected by Engineer.

C. Raceways

1. Conduit which enters equipment such as switchgear, motor control centers, transformers, panelboards, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

### 3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

B. Witnessed Shop Tests

1. None required.

C. Field Tests

1. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.
2. Ground Resistance Tests:
  - a. Computer-based grounding multimeter shall be performed in accordance with IEEE 81, Section 8.2.2.7 by a third party, independent testing firm for measurement of each building's or structure's main ground system resistance. Testing shall measure the main ground electrode system resistance to be less than 1.0 ohm.
  - b. Fall of potential tests shall be performed in accordance with IEEE81, Section 8.2.2.4 by a third party, independent testing firm to measure the ground resistance between the main ground system, equipment frames, and system neutral points. A fall of potential plot shall be submitted at the conclusion of testing for Engineer review. Documentation indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made shall be submitted. Testing shall measure 0.5 ohms resistance or less. Due to soil conditions and/or unforeseen field conditions, ground resistances greater than 0.5 ohms may

be acceptable if specifically approved in writing by the Engineer. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground grid under test isolated from other grounds.

3. Continuity tests for the grounding electrode conductor shall be performed. Test will be accepted when a resistance of less than 1 ohm is shown for this conductor.

**END OF SECTION**

**SECTION 26 05 29**  
**HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install structural supports for mounting and installing all conduit, electrical equipment, lighting, alarm systems, instrumentation, and communications equipment furnished under this Contract.
- B. Equipment shall be installed strictly in accordance with recommendations of the manufacturer and best practices of the trade resulting in a complete, operable, and safe installation. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation.
- C. Reference Section 26 05 00 – Basic Electrical Requirements.

**1.02 CODES AND STANDARDS**

- A. Equipment and materials covered under this Section shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. ASTM A123 – Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. ASTM A153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
  - 3. ASTM A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
  - 4. ASTM A276 – Standard Specification for Steel Bars and Shapes
  - 5. ASTM B783 – Standard Specification for Materials for Ferrous Powder Metallurgy Structural Parts

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop drawings

2. Structural support calculations (if required)

B. Each submittal shall be identified by the applicable Specification section.

**1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

**PART 2 – PRODUCTS**

**2.01 MANUFACTURERS**

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

**2.02 MATERIALS**

A. Support channel shall be 1-5/8" by 1-5/8" minimum, with 12 gage material thickness.

B. Support channel, support channel fittings, and threaded rod shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

<b>Area Designation</b>	<b>Material of Construction</b>
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Hot Dipped Galvanized Steel
Indoor Dry Non-process Area	Hot Dipped Galvanized Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

C. Fastening hardware (bolts, nuts, washers, and screws) shall be furnished with the following material of construction, dependent upon the designation of the area in which

they are to be installed. Area designations are indicated on the Drawings.

<b>Area Designation</b>	<b>Material of Construction</b>
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Type 304 Stainless Steel
Indoor Dry Non-process Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

#### **A. Concrete or Masonry Inserts**

1. The Contractor shall be responsible for the furnishing and installation of all anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.
2. If a time delay for the arrival of any special inserts or equipment drawings, etc. occurs, the Contractor may, if permitted by the Engineer, make arrangements for providing approved recesses and openings in the concrete or masonry and, upon subsequent installation, the Contractor shall be responsible for filling in such recesses and openings. Any additional costs that may be incurred by this procedure shall be borne by the Contractor.
3. The Contractor shall furnish leveling channels for all switchgear, switchboards, motor control centers, and similar floor mounted equipment. The leveling channels shall be provided for embedment in the equipment housekeeping pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain concrete coverage of the reinforcement bars while not causing associated equipment to exceed the maximum mounting height requirements of the NEC.

#### **B. Support Fastening and Locations**

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel.
2. Unless otherwise indicated on the Drawings or in the Specifications, handrails/guardrails shall not be utilized as supports for electrical equipment, devices, or appurtenances. Handrails/guardrails shall not be cut, drilled, or otherwise modified in order to accommodate electrical supports without written approval from the Engineer.

3. All holes made in reflected ceilings for support rods, conduits, and other equipment shall be made adjacent to ceiling grid bars where possible, to facilitate removal of ceiling panels.
4. Support channel shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.
5. All equipment, devices, and raceways that are installed on the dry side of a water bearing wall shall not be installed directly onto the wall. Support channel shall be used to allow ventilation air to pass behind the equipment, devices, or raceway.
6. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework.
7. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.
8. Actual designs for supporting framework should take the nature of a picture frame of support channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; Contractor shall submit design details to the Engineer for acceptance before proceeding with the fabrication.
9. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.
10. For all installations where fiberglass supporting materials are required, the Contractor shall submit structural calculations and the details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the state in which the project is located.
11. For the following installations where conduits are provided with a support system suspended from the above or attached to a vertical structure, the Contractor shall submit structural calculations and details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the state in which the project is located.
  - a. A quantity of twelve (12) or more conduits trade size 1" and smaller are proposed for a conduit support rack.
  - b. A quantity of eight (8) or more conduits trade sizes 1 1/2" to 2 1/2" are proposed for a conduit support rack.



- c. A quantity of four (4) or more conduits trade sizes 3" and larger are proposed for a conduit support rack.
- 12. Single conduits installed exposed along walls and ceilings shall be secured to the wall or ceiling with a one-hole conduit clamp and clamp-back. Where multiple conduits are installed exposed together, support channel and conduit clamps shall be used.
- C. Equipment, boxes, and enclosures which are factory-constructed with integral mounting provisions (such as brackets., mounting feet, bolt holes, etc.) shall be installed/supported utilizing those mounting provisions. Equipment, boxes and enclosures shall not be field-modified by any means which compromises the UL listing or NEMA rating of the enclosure/assembly shall be removed and replaced by the Contractor at no additional cost to the Owner.

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**SECTION 26 05 33.13**  
**CONDUIT FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install conduits and conduit fittings to complete the installation of all electrically operated equipment as specified herein, indicated on the Drawings, and as required.
- B. Requirements for conduit clamps, support systems, and anchoring are not included in this Section. Reference Section 26 05 29 – Hangers and Supports for Electrical Systems, for these requirements.
- C. Reference Section 26 05 00 – Basic Electrical Requirements.

**1.02 CODES AND STANDARDS**

- A. Conduits and conduit fittings shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. American National Standards Institute (ANSI)
    - a. ANSI B1.20.1 – Pipe Threads, General Purpose
    - b. ANSI C80.1 – Electrical Rigid Steel Conduit
    - c. ANSI C80.5 – Electrical Rigid Aluminum Conduit
    - d. ANSI FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
  - 2. Underwriters Laboratories (UL)
    - a. UL 1 – Standard for Flexible Metal Conduit
    - b. UL 6 – Electrical Rigid Metal Conduit-Steel
    - c. UL 6A – Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel
    - d. UL 360 – Standard for Liquid-tight Flexible Metal Conduit
    - e. UL 467 – Grounding and Bonding Equipment
    - f. UL 514B – Conduit, Tubing, and Cable Fittings

- g. UL 651 – Standard for Schedule 40 and 80 Conduit and Fittings
  - h. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations
  - i. UL 1479 – Standard for Fire Tests of Penetration Fire Stops
3. National Electrical Manufacturer’s Association (NEMA)
- a. NEMA RN 1 – PVC Externally Coated Galvanized Rigid Steel Conduit
  - b. NEMA RV-3 – Application and Installation Guidelines for Flexible and Liquid-tight Flexible Metal and Nonmetallic Conduits
  - c. NEMA TC-2 – Electrical PVC Conduit
  - d. NEMA TC-3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
- B. Others
- 1. ACI-318 – Building Code Requirements for Structural Concrete

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
- 1. Shop Drawings
- B. Each submittal shall be identified by the applicable specification section.

**1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
- 1. Product data sheets for conduits and fittings.
  - 2. Conduit identification methods and materials.

3. Evidence of training for all personnel that will install PVC coated rigid metal conduit.

## **1.05 DEFINITIONS**

- A. Conduits are categorized by the circuit type of the wiring to be installed inside. Conduits are defined as follows:
  1. Power Conduits – Conduits that carry AC or DC power wiring from a source to a load. Conduits that carry lighting and receptacle wiring.
  2. Control Conduits – Conduits that carry AC or DC discrete control wiring between devices and/or equipment. Conduits that carry fiber optic cables between devices and/or equipment.
  3. Instrumentation Conduits – Conduits that carry AC or DC analog signal wiring between devices and/or equipment.
- B. Conduit categories are indicated on the Drawings by the leading letter of the conduit tag. Conduit tag leading letters are defined as follows:
  1. P – Power Conduit
  2. C – Control Conduit
  3. I – Instrumentation Conduit

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. Conduit and conduit fitting products are specified in the text that follows this article. Reference Part 3 herein for the application, uses and installation requirements of these conduits and conduit fittings.
- B. All metallic conduit fittings shall be UL 514B and UL 467 Listed and constructed in accordance with ANSI FB 1. All metallic conduit fittings for use in Class I Division I hazardous areas shall be UL 1203 Listed. All non-metallic fittings shall be UL 651 Listed and constructed in accordance with NEMA TC-3.
- C. Flexible conduit couplings for use in Class I Division I hazardous areas shall have threaded stainless steel end fittings and a flexible braided core. Flexible braid shall be constructed of stainless steel where available in the conduit trade size required for the application. Where stainless steel braid is not available, the braid shall be provided with a PVC coating. No other braid types or materials are acceptable.

- D. Where threading is specified herein for conduit fitting connections, the fittings shall be manufactured to accept conduit that is threaded to ANSI B1.20.1 requirements.
- E. Conduit expansion fittings for all conduit materials of construction shall be capable of 4 inches of movement along the axis of the conduit for trade sizes 2 inches or less. Expansion fittings shall be capable of 8 inches of movement along the axis of the conduit for trade sizes greater than 2 inches.
- F. Conduit deflection fittings for all conduit materials of construction shall be provided with a flexible neoprene outer jacket that permits up to  $\frac{3}{4}$  inch of expansion/contraction along the axis of the conduit as well as up to  $\frac{3}{4}$  inch of parallel misalignment between the conduit axes. Outer jacket shall be secured to the conduit hubs by stainless steel clamps.
- G. Conduit seals shall either be Listed and labeled for 40% fill, or conduit reducing fittings and a trade size larger conduit seal shall be provided to achieve 25% or less fill within the seal. Percentage fill calculation shall be based on the conductors to be installed. Conduit seals shall be provided with breathers and/or drains where required by the NEC.
- H. Conduit insulating bushings shall be constructed of plastic and shall have internal threading.
- I. Additional conduit and conduit fitting requirements are specified in the articles that follow based on the specific conduit material of construction to be used.

## **2.02 RIGID GALVANIZED STEEL (RGS) CONDUIT AND ASSOCIATED FITTINGS**

### **A. Conduit**

- 1. Conduit shall be hot dip galvanized on the inside and outside and made of heavy wall high strength ductile steel. Conduit shall be manufactured in accordance with ANSI C80.1 and shall be UL 6 Listed.
- 2. Conduit shall be provided with factory-cut  $\frac{3}{4}$  inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.

### **B. Conduit Bodies for use with Rigid Galvanized Steel**

- 1. Conduit bodies shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Conduit bodies shall have integral threaded conduit hubs.

2. Conduit bodies for Class I Division I hazardous areas shall be provided with integrally threaded covers constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish.
3. Conduit bodies for all other areas shall be provided with covers that are affixed in place by stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Covers shall be provided with matching gasket.

C. Conduit Couplings, Nipples, and Unions for use with Rigid Galvanized Steel

1. Couplings and nipples shall be threaded and shall be constructed of hot dipped galvanized steel. Split-type couplings that use compression to connect conduits are not acceptable.
2. Unions shall be threaded, rain-tight, and constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish.

D. Conduit Expansion and Deflection Fittings for use with Rigid Galvanized Steel

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Expansion and deflection fittings shall have threaded conduit connections.
2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

E. Conduit Seals for use with Rigid Galvanized Steel

1. Conduit seals shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Conduit seals shall have threaded conduit connections.

F. Conduit Termination Fittings for use with Rigid Galvanized Steel

1. Conduit hubs shall be constructed of stainless steel and shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
2. Conduit locknuts shall be constructed of zinc plated steel. Locknuts shall have internal threading. Locknuts with integral gasket or seal are not acceptable. Locknuts shall have integral bonding screw where required for proper bonding.
3. Conduit bonding bushings shall be constructed of zinc plated malleable iron. Bonding bushings shall have a threaded conduit connection. Bonding bushing

shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

## **2.03 RIGID NONMETALLIC CONDUIT AND ASSOCIATED FITTINGS**

### **A. Conduit**

1. Conduit shall be Schedule 40 or 80 (dependent on application) polyvinyl chloride (PVC) construction, manufactured in accordance with NEMA TC-2, UL 651 Listed, and suitable for conductors with 90 degree C insulation.

### **B. Conduit Bodies for use with Rigid Nonmetallic Conduit**

1. Conduit bodies shall be constructed of PVC. Conduit hubs shall be integral to the conduit body and shall be smooth inside to accept a glued conduit connection.
2. Conduit body shall be provided with cover that is affixed in place by stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

### **C. Conduit Couplings and Unions for use with Rigid Nonmetallic Conduit**

1. Conduit couplings and unions shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection.

### **D. Conduit Expansion and Deflection Fittings for use with Rigid Nonmetallic Conduit**

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection.

### **E. Conduit Termination Fittings for use with Rigid Nonmetallic Conduit**

1. Conduit hubs shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection. Hubs shall have external threads and an accompanying PVC locknut, and shall be watertight when assembled to an enclosure.
2. Conduit locknuts shall be constructed of zinc plated steel. Locknuts shall have internal threading. Locknuts constructed of PVC and locknuts with integral gasket or seal are not acceptable.
3. Conduit end bells shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection. End bell shall have a smooth inner surface that curves outward towards the edge of the fitting.

## **2.04 PVC COATED RIGID GALVANIZED STEEL CONDUIT AND ASSOCIATED FITTINGS**

### **A. General**



1. Where an external coating of polyvinyl chloride (PVC) is specified for conduit and fittings, the coating shall be 40 mil (minimum) thickness. Where an internal coating of urethane is specified for conduit and fittings, the coating shall be 2 mil (minimum) thickness.
2. All conduit fittings shall have a sealing sleeve constructed of PVC which covers all connections to conduit. Sleeves shall be appropriately sized so that no conduit threads will be exposed after assembly.

#### B. Conduit

1. Conduit shall be hot dip galvanized on the inside and outside and made of heavy wall high strength ductile steel. Conduit shall be manufactured in accordance with ANSI C80.1 and shall be UL 6 Listed.
2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.
3. Conduit shall be coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit shall be manufactured in accordance with NEMA RN-1.

#### C. Conduit Bodies for use with PVC Coated Rigid Galvanized Steel Conduit

1. Conduit bodies shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit bodies shall have integral threaded conduit hubs.
2. Conduit bodies for Class I Division I hazardous areas shall be provided with integrally threaded covers constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.
3. Conduit bodies for all other areas shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Covers shall be affixed in place by stainless steel screws which thread directly into the conduit body and have a plastic encapsulated head. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

#### D. Conduit Couplings, Nipples, and Unions for use with PVC Coated Rigid Galvanized Steel Conduit

1. Couplings and nipples shall be threaded and shall be constructed of hot dipped galvanized steel which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Split-type couplings that use compression to connect conduits are not acceptable.
  2. Unions shall be threaded, rain-tight, and constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.
- E. Conduit Expansion and Deflection Fittings for use with PVC Coated Rigid Galvanized Steel Conduit
1. Conduit expansion fittings and conduit deflection fittings shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Expansion and deflection fittings shall have threaded conduit connections.
  2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.
- F. Conduit Seals for use with PVC Coated Rigid Galvanized Steel Conduit
1. Conduit seals shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit seals shall have threaded conduit connections.
- G. Conduit Termination Fittings for Use with PVC Coated Rigid Galvanized Steel Conduit
1. Conduit hubs shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Hubs shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
  2. Conduit bonding bushings shall be constructed of zinc plated malleable iron which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

## **2.05 RIGID ALUMINUM CONDUIT AND ASSOCIATED FITTINGS**

### **A. Conduit**

1. Conduit shall be made of heavy wall high strength 6063 alloy aluminum with temper designation T1. Conduit shall be manufactured in accordance with ANSI C80.5 and shall be UL 6A Listed.
2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.

B. Conduit Bodies for use with Rigid Aluminum Conduit

1. Conduit bodies shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Conduit bodies shall have integral threaded conduit hubs.
2. Conduit bodies for Class I Division I hazardous areas shall be provided with integrally threaded covers constructed of copper-free aluminum which is coated with an aluminum enamel finish.
3. Conduit bodies for all other areas shall be provided with stamped copper-free aluminum covers that are affixed in place by stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

C. Conduit Couplings, Nipples, and Unions for use with Rigid Aluminum Conduit

1. Couplings and nipples shall be threaded and shall be constructed of heavy wall high strength 6063 alloy aluminum with temper designation T1. Split-type couplings that use compression to connect conduits are not acceptable.
2. Unions shall be threaded, rain-tight, and constructed of copper-free aluminum which is coated with an aluminum enamel finish.

D. Conduit Expansion and Deflection Fittings for use with Rigid Aluminum Conduit

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Expansion and deflection fittings shall have threaded conduit connections.
2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

E. Conduit Seals for use with Rigid Aluminum Conduit

1. Conduit seals shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Conduit seals shall have threaded conduit connections.

F. Conduit Termination Fittings for use with Rigid Aluminum Conduit

1. Conduit hubs shall be constructed of copper-free aluminum and shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
2. Conduit locknuts shall be constructed of copper-free aluminum. Locknuts shall have internal threading. Locknuts with integral gasket or seal are not acceptable. Locknuts shall have integral bonding screw where required for proper bonding.
3. Conduit bonding bushings shall be constructed of copper-free aluminum. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

**2.06 LIQUID TIGHT FLEXIBLE METAL CONDUIT (LFMC) AND ASSOCIATED FITTINGS**

A. Conduit

1. Conduit shall be manufactured using a single strip of hot dip galvanized high strength steel alloy, helically formed into a continuously interlocked flexible metal conduit. Trade size 1-1/4 inch and smaller conduits shall be provided with an integrally woven copper bonding strip.
2. Conduit shall be covered with an outside PVC jacket that is UV resistant, moisture-proof, and oil-proof. Conduit shall be UL 360 Listed.

B. Conduit Termination Fittings for use with LFMC

1. Conduit termination fittings shall be constructed of either 304 stainless steel or an electro-galvanized malleable iron alloy which is coated on the exterior with a 40 mil (minimum) PVC jacket and coated on the interior with a 2 mil (minimum) layer of urethane. PVC coated fittings shall have a sealing sleeve constructed of PVC which covers the connection to conduit.
2. Termination fittings shall have a threaded end with matching locknut and sealing ring for termination to equipment and shall have an integral external bonding lug where required for proper bonding. Termination fittings shall have a plastic insulated throat and shall be watertight when assembled to the conduit and equipment.

**2.07 LIQUID TIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC) AND ASSOCIATED FITTINGS (NOT USED)**

**2.08 FLEXIBLE METAL CONDUIT (FMC) AND ASSOCIATED FITTINGS**

A. Conduit

1. Conduit shall be manufactured using a single strip of hot dip galvanized high strength steel alloy, helically formed into a continuously interlocked flexible metal conduit. Conduit shall be UL 1 Listed.

B. Conduit Termination Fittings for use with FMC

1. Conduit termination fittings shall be constructed of an electro-galvanized malleable iron alloy. Fittings shall have a threaded end with matching locknut for termination to equipment, and a compression-style connection to the associated conduit.

**2.09 ELECTRICAL METALLIC TUBING (EMT) AND ASSOCIATED FITTINGS (NOT USED)**

**2.10 CONDUIT BENDS**

- A. Rigid conduit bends, both factory-fabricated and field-fabricated, shall meet the same requirements listed in the articles above for the respective conduit type and material of construction.

- B. Conduit bend radii for standard radius bends shall be no less than as follows:

<b>Trade Size (inches)</b>	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
<b>Min. Radius (inches)</b>	4-1/2	5-3/4	7-1/4	8-1/4	9-1/2	10-1/2	13	15	16	24	30

- C. Conduit bend radii for long radius bends shall be no less than as follows:

<b>Trade Size (inches)</b>	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
<b>Min. Radius (inches)</b>	N/A	12	18	24	30	30	36	36	48	48	60

**2.11 MISCELLANEOUS**

A. Conduit Periphery Sealing

1. The sealing of the exterior surface of conduits to prevent water and/or air from passing around the conduit periphery from one space to another (where required) shall be through the use of one of the following:

- a. A conduit sleeve and pressure bushing sealing system. Acceptable products are FSK by OZ-GEDNEY, Link-Seal by Crouse-Hinds, or Engineer approved equal.
  - b. A conduit sleeve that is two trade sizes larger than the conduit being sealed, with 2-hour fire rated UL 1479 Listed caulk filling the entire void between the conduit and sleeve. This method is only suitable for penetrations in non-fire rated walls and floors between spaces within buildings. This method shall not be used for the sealing of conduits leaving a building and/or structure.
2. Conduit penetrations through fire-rated walls and floors shall be made with an approved UL 1479 Listed product specifically intended for the trade size of the conduit.

#### B. Primer and Cement

1. Nonmetallic conduit shall be cleaned with primer and connected to fittings with the manufacturer's recommended cement that is labeled Low VOC.

#### C. Galvanizing Compounds

1. Galvanizing compounds for field application shall be the cold-applied type, containing no less than 93% pure zinc.

#### D. Conduit Interior Sealing

1. The sealing of the inside of conduits against water ingress shall be achieved through the use of one of the following:
  - a. Two-part expanding polyurethane foam sealing compound, dispensed from a single tube which mixes the two parts as it is injected into the conduit. Expanding foam shall be compatible with the conduit material of construction as well as the outer jacket of the cables in the conduit. Acceptable products are Q-Pak 2000 by Chemque, FST by American Polywater Corporation, or Hydra-seal S-60 by Duraline.
  - b. Inflatable bag that provides seal around cables and around inside diameter of conduit. Provide appropriate quantity of additional fittings for applications with three or more cables in the conduit to be sealed. Acceptable products are Rayflate by Raychem, or Engineer approved equal. This sealing method is only applicable to conduits trade size 2 inch and larger.
  - c. Neoprene sealing ring provided with the required quantity and diameter of holes to accommodate the cables in each conduit. Sealing ring shall be compressed by two stainless steel pressure plates. Acceptable products are type CSB by OZ-GEDNEY, or Engineer approved equal. This sealing method is only applicable to metallic conduits containing 4 or less cables.

2. The use of aerosol-based expanding foam sealants or any other method of sealing against water ingress not listed above is not acceptable.

E. Pull Rope

1. Pull ropes for empty and/or spare conduits shall be woven polyester, ½-inch wide, with a minimum tensile strength of 1250 lbs.
2. Pull ropes for the Contractors use in installing conductors shall be the size and strength required for the pull and shall be made of a non-metallic material.

## **PART 3 – EXECUTION**

### **3.01 GENERAL**

- A. Minimum trade size for all rigid conduits shall be ¾ inch in exposed applications and 1 inch in embedded applications. Conduits installed within ductbanks shall be allowed to be increased in size to trade size 2 inch, at the Contractor's option, to accommodate the saddle size of the ductbank spacers. However, no combining of circuits shall be allowed in the larger conduits.
- B. Minimum trade size for flexible conduits (where specifically allowed herein) shall be 1/2 inch in all applications.
- C. Conduit routing and/or homeruns within structures is not shown on the Drawings. Conduits shall be installed concealed wherever practical and within the limitations specified herein. All other conduits not capable of being installed concealed shall be installed exposed.
- D. Empty and/or spare conduits shall be provided with pull ropes which have no less than 12 inches of slack at each end.
- E. Nonmetallic conduits for installations requiring less than a factory length of conduit shall be field cut to the required length. The cut shall be made square, cleaned of debris, and primer shall be applied to ready each joint for fusing. Conduits shall then be fused together with the conduit manufacturer's approved cement compound.
- F. Metallic conduits for installations requiring less than a factory length of conduit shall be field cut to the required length. The cut shall be made square, be cleaned of all debris and be de-burred, then threaded. Conduit threading performed in the field shall be ¾ inch per foot tapered threads in accordance with ANSI B1.20.1.
- G. Conduits shall be protected from moisture, corrosion, and physical damage during construction. Install dust-tight and water-tight conduit fittings on the ends of all conduits immediately after installation and do not remove until conductors are installed.

- H. Conduits shall be installed to provide no less than 12 inches clearance from pipes that have the potential to impart heat upon the conduit. Such pipes include, but are not limited to, hot water pipes, steam pipes, exhaust pipes, and blower air pipes. Clearance shall be maintained whether conduit is installed in parallel or in crossing of pipes.
- I. Where non-metallic instrumentation conduits are installed exposed, the following clearances to other conduit types shall be maintained:
  - 1. Instrumentation conduits installed parallel to conduits with conductors energized at 480V or above shall be 18 inches.
  - 2. Instrumentation conduits installed parallel to conduits with conductors energized at 240V and below shall be 12 inches.
  - 3. Instrumentation conduits installed at right angles to conductors energized at 480V and below shall be 6 inches.
  - 4. Instrumentation conduits installed at right angles to conductors energized at voltages above 480V shall be 12 inches.
- J. Where conduit fittings do not include an integral insulated bushing, an insulated bushing shall be installed at all conduit termination points.
- K. Conduits which serve multi-section equipment shall be terminated in the section where wiring terminations will be made.
- L. Conduits shall not penetrate the floors or walls inside liquid containment areas without specific written authorization from the Engineer. Liquid containment areas are indicated on the Drawings.
- M. In no case shall conduit be supported or fastened to another pipe or be installed in a manner that would prevent the removal of other pipes for repairs. Spring steel fasteners may only be used to affix conduits containing lighting branch circuits within EMT conduits to structural steel members.
- N. All field fabricated threads for rigid galvanized steel conduit shall be thoroughly coated with two coats of galvanizing compound, allowing at least two minutes to elapse between coats for proper drying.
- O. The appropriate specialized tools shall be used for the installation of PVC coated conduit and conduit fittings. No damage to the PVC coating shall occur during installation. Conduit and conduit fittings with damaged PVC coating shall be replaced at the Contractor's cost. The use of PVC coating touch-up compounds is not permitted.
- P. Conduits which emerge from within or below concrete encasement shall be PVC coated rigid galvanized steel in accordance with Standard Detail E-26-0102 where the conduit is



not protected by an equipment enclosure that surrounds the conduit on all sides at the point where it emerges from the encasement.

- Q. Aluminum conduits shall not be installed in direct contact with concrete surfaces. Where aluminum conduits are routed along concrete surfaces, they shall be installed with one-hole electro-galvanized malleable iron alloy straps with matching clamp-backs to space the conduit  $\frac{1}{4}$  inch away from concrete surface. Where aluminum conduit passes through concrete, CMU or brick walls, the penetration shall be made such that the aluminum conduit does not come in contact with concrete, CMU, brick or mortar.

### **3.02 CONCEALED AND EMBEDDED CONDUITS**

- A. Conduits are permitted to be installed concealed and/or embedded with the following requirements:
1. Conduits shall not be installed horizontally when concealed within CMU walls, only vertical installation is acceptable.
  2. Conduits installed embedded within concrete floors or walls shall be located so as not to affect the designed structural strength of the floor or wall. Embedded conduits shall be installed in accordance with Standard Detail S-03-0403 and ACI-318.
  3. Where conduit bends emerge from concrete embedment, none of the curved portion of the bend shall be visible. Only the straight portion of the bend shall be visible. The straight portion shall emerge perpendicular to the embedment (i.e. neatly oriented 90-degrees to floor/slab/grade). Conduits that emerge in a non-perpendicular orientation are not acceptable.
  4. Where multiple conduits emerge from concrete embedment or from concealment below a concrete floor, ample clear space shall be provided between conduits to allow for the appropriate and required conduit termination fittings to be installed.
  5. Conduits installed embedded within concrete encasement of any kind shall be installed such that conduit couplings for parallel conduits are staggered so that they are not side by side.
- B. Conduits are NOT permitted to be installed concealed and/or embedded for the following situations:
1. Conduits shall not be installed embedded within any water-bearing floors or walls. Conduits shall not be installed embedded within any liquid containment area floors or walls.
  2. Conduits shall not be installed concealed within CMU walls or gypsum walls that are adjacent to Class I and II hazardous areas (Division I and Division II).

3. Conduits shall not be installed concealed within CMU walls or gypsum walls that are adjacent to indoor Type 1 or Type 2 chemical storage/transfer areas.

### 3.03 CONDUIT USES AND APPLICATIONS

#### A. Rigid Conduit

Rigid conduit for non-hazardous areas shall be furnished and installed in the materials of construction as follows:

<b>Rigid Conduit for Non-Hazardous Areas</b>		
<b>Installation Area Designation / Scenario</b>	<b>Conduit Category by Wiring / Circuit Type</b>	
	<b>Power and Control</b>	<b>Instrumentation</b>
Exposed in indoor wet process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in indoor dry process areas	Rigid galvanized steel conduit	Same as Power and Control
Exposed in indoor dry non-process areas	Rigid galvanized steel conduit	Same as Power and Control
Exposed in outdoor areas	Rigid aluminum conduit	Same as Power and Control
Concealed within underground direct-bury or concrete-encased ductbanks	Schedule 40 rigid non-metallic PVC conduit	Rigid galvanized steel conduit
Concealed within non-elevated (i.e. "slab-on-grade" construction) concrete slabs	Schedule 40 rigid non-metallic PVC conduit	Rigid galvanized steel conduit
Concealed within elevated concrete slabs	Rigid galvanized steel conduit	Same as Power and Control
Concealed below concrete slabs (within earth or fill material)	Schedule 40 rigid non-metallic PVC conduit	Rigid galvanized steel conduit
Concealed within concrete walls	Schedule 40 rigid non-metallic PVC conduit	Rigid galvanized steel conduit
Concealed within CMU walls	Schedule 40 rigid non-metallic PVC conduit or Electrical Metallic Tubing	Rigid galvanized steel conduit or Electrical Metallic Tubing

<b>Rigid Conduit for Non-Hazardous Areas</b>		
<b>Installation Area Designation / Scenario</b>	<b>Conduit Category by Wiring / Circuit Type</b>	
	<b>Power and Control</b>	<b>Instrumentation</b>
Emerging from concealment within or below a concrete floor and transitioning to exposed conduit (Reference Detail E-26-0102)	PVC coated rigid galvanized steel conduit	Same as Power and Control

1. Rigid conduit for hazardous areas shall be furnished and installed in the materials of construction as follows:

<b>Rigid Conduit for Hazardous Areas</b>		
<b>Installation Area Hazard / Scenario</b>	<b>Conduit Category by Wiring / Circuit Type</b>	
	<b>Power and Control</b>	<b>Instrumentation</b>
Exposed in Class I and II areas (Division I and Division II)	Rigid aluminum conduit	Same as Power and Control
Concealed within concrete slabs in Class I and II areas (Division I and Division II)	Rigid galvanized steel conduit	Same as Power and Control
Concealed below concrete slabs (within earth or fill material) in Class I and II areas (Division I and Division II)	Rigid galvanized steel conduit	Same as Power and Control
Concealed within concrete walls in Class I and II areas (Division I and Division II)	Rigid galvanized steel conduit	Same as Power and Control
Concealed below concrete slabs encased in at least two inches of concrete and buried 24 inches below top of slab in Class I Division I areas	Schedule 40 rigid non-metallic PVC conduit	Rigid galvanized steel conduit

2. The tables for the materials of construction for rigid conduits are intended to exhaustively cover all possible scenarios and installation areas under this Contract. However, if a scenario or installation area is found that is not explicitly governed by these tables, it shall be assumed for bid purposes that the conduit material of construction is to be rigid galvanized steel. This discrepancy shall be brought to the attention of the Engineer (in writing) immediately for resolution.

## B. Conduit Bends

1. All conduit bends shall be the same material of construction as the rigid conduit listed in the tables above, with the following exceptions:
  - a. All 90-degree bends or combinations of adjacent bends that form a 90-degree bend where concealed within concrete or below a concrete slab shall be rigid galvanized steel.
2. Field fabricated bends of metallic conduit shall be made with a bending machine and shall have no kinks. Field fabricated standard radius and long radius bends shall have minimum bending radii in accordance with the associated tables in Part 2 herein.
3. Field bending of non-metallic conduits is not acceptable, factory fabricated bends shall be used.
4. Long radius bends shall be furnished and installed for the following specific applications, all other bends shall be standard radius:
  - a. All conduits containing fiber optic cable.
  - b. Where specifically indicated on the Drawings.

## C. Flexible Conduit

1. Flexible conduit shall only be installed for the limited applications specified herein. Flexible conduit shall not be installed in any other application without written authorization from the Engineer. Acceptable applications are as follows:
  - a. Connections to motors and engine-generator sets (and similar vibrating equipment)
  - b. Connections to solenoid valves and limit switches
  - c. Connections to lighting fixtures installed in suspended ceilings
  - d. Connections to lighting transformers
  - e. Connections to pre-fabricated equipment skids
  - f. Connections to HVAC equipment
  - g. Connections to instrument transmitters and elements
  - h. Where specifically indicated in the Standard Details

2. Flexible conduit length shall be limited to three (3) feet, maximum. Flexible conduit shall not be installed buried or embedded within any material.
3. Unless otherwise specified herein, flexible conduits shall be installed in accordance with the Installation Guidelines published within NEMA RV-3.
4. Flexible conduit for non-hazardous areas shall be furnished and installed in the materials of construction as follows:

<b>Flexible Conduit for Non-Hazardous Areas</b>		
<b>Installation Area Designation / Scenario</b>	<b>Conduit Category by Wiring / Circuit Type</b>	
	<b>Power and Control</b>	<b>Instrumentation</b>
Exposed in indoor wet process areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in indoor dry process areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in indoor dry non-process areas	Flexible metal conduit	Same as Power and Control
Exposed in outdoor areas	Liquid-tight flexible metal conduit	Same as Power and Control
Concealed above suspended ceilings (all indoor areas)	Same material as exposed conduit in same area	Same as Power and Control

5. For Class I Division I hazardous areas, the NEC does not permit the installation of flexible conduit. In lieu of flexible conduit in these areas, flexible conduit couplings shall be installed as specified in Part 2 herein. Flexible conduit for all other hazardous areas shall be furnished and installed in the materials of construction as follows:

<b>Flexible Conduit for Hazardous Areas</b>		
<b>Installation Area Hazard / Scenario</b>	<b>Conduit Category by Wiring / Circuit Type</b>	
	<b>Power and Control</b>	<b>Instrumentation</b>
Exposed in Class I Division II areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in Class II (Division I and Division II) areas	Liquid-tight flexible metal conduit	Same as Power and Control
Concealed above suspended ceilings in Class I and II (Division I and Division II) areas	Same material as exposed conduit in same area	Same as Power and Control

### 3.04 CONDUIT FITTING USES AND APPLICATIONS

#### A. General

1. Conduit fittings shall be furnished and installed in the materials of construction as indicated in Part 2, herein. Conduit fitting materials of construction are dependent on the material of construction used for the associated conduit.
2. Conduit fittings shall be provided in the trade size and configuration required to suit the application.

#### B. Conduit Bodies

1. Conduit bodies shall be installed where wire pulling points are desired or required, or where changes in conduit direction or breaking around beams is required.
2. Where conduit bodies larger than trade size 2 inches are intended to be used as a pull-through fitting during wire installation, oversized or elongated conduit bodies shall be used. Oversized or elongated conduit bodies shall not be required if the conduit body is intended to be used as a pull-out point during wire installation.

#### C. Conduit Nipples and Unions

1. Conduits with running threads shall not be used in place of 3-piece couplings (unions) or close nipples. After installation of a conduit fitting of any kind, there shall be no more than ¼ inch of exposed threads visible. Factory fabricated all-thread nipples may be used between adjacent enclosures, however, the same restriction applies regarding the length of exposed threads that are visible.

#### D. Conduit Expansion and Deflection Fittings

1. Conduit expansion fittings shall be installed where required by the NEC and where indicated on the Drawings. Expansion fittings shall also be installed for exposed straight metallic conduit runs of more than 75 feet, in both indoor and outdoor locations. Expansion fittings for runs of non-metallic conduit shall be installed in accordance with the NEC.
2. Conduit deflection fittings shall be installed where required by the NEC and where conduits are installed (exposed and concealed) across structural expansion joints.

#### E. Conduit Seals

1. Conduit seals shall be installed for conduits installed within or associated with hazardous areas and other areas as required by the NEC.

#### F. Conduit Termination Fittings

1. Where conduits terminate at enclosures with a NEMA 4, 4X, or 3R rating and the enclosure does not have integral conduit hubs, an appropriately sized watertight conduit hub shall be installed to maintain the integrity of the enclosure. The use of locknuts with integral gasket in lieu of watertight conduit hubs is not acceptable.
2. Where conduits terminate at enclosures that do not require conduit hubs, a two-locknut system shall be used to secure the conduit to the enclosure. One locknut shall be installed on the outside of the enclosure, and the other inside, drawn tight against the enclosure wall. The locknut on the interior of the enclosure shall be the type with integral bonding lug, or a conduit bonding bushing may be used in place of the locknut.
3. Conduits shall not be installed such that conduit fittings penetrate the top of any enclosure located outdoors, except in cases where specifically required by the serving electric utility. Conduits which serve outdoor equipment or an enclosure from above shall instead be routed into the side of the enclosure at the bottom. The conduit termination fitting shall be provided with a conduit drain to divert moisture from the raceway away from the enclosure.

### 3.05 MISCELLANEOUS

#### A. Conduit Periphery Sealing

1. All conduit penetrations through exterior walls shall be sealed around the periphery using the appropriate products specified in Part 2 herein to prevent air and/or water entry into the structure.
2. All conduit penetrations through interior walls and floors shall be sealed through the use of with conduit sleeves and caulk as specified in Part 2 herein. Alternatively, mortar may be used to seal around the conduit periphery.

3. Conduit penetrations through fire-rated walls as floors shall be made with the appropriate fire rated penetration product.

B. Conduit Interior Sealing

1. All conduits (including spares) entering a structure below grade shall be sealed on the interior of the conduit against water ingress. Sealing shall be at an accessible location in the conduit system located within the building structure and shall be via one of the methods specified in Part 2 herein. If conduit sealing cannot be achieved at an accessible location within the building structure, sealing shall be placed in the conduits in the nearest manhole or handhole outside the structure.

### 3.06 CONDUIT IDENTIFICATION

- A. Exposed conduits shall be identified at the source, load, and all intermediate components of the raceway system. Examples of intermediate components include but are not limited to junction boxes, pull boxes, and disconnect switches. Identification shall be by means of an adhesive label with the following requirements:
1. Labels shall consist of an orange background with black text. Text for the label shall be the conduit number as indicated in the conduit and wire schedules.
  2. In addition, at the source end of the conduit, a second line of text shall be included to indicate the load equipment name. This second line shall consist of the word "TO:" and the text in the 'TO' column of the conduit and wire schedule (e.g. TO: INF-P-1). At the load end of the conduit, a second line of text shall be included to indicate the source equipment name. This second line shall consist of the word "FROM:" and the text in the 'FROM' column of the conduit and wire schedule (e.g. FROM: MCC). This requirement applies only to the source and load ends of the conduit, and not anywhere in between.
  3. For conduits trade sizes 3/4 inch through 1-1/2 inch, the text shall be a minimum 18-point font. For conduits trade size 2 inch and larger, the text shall be a minimum 24-point font.
  4. Label height shall be 3/4 inch minimum, and length shall be as required to fit required text. The label shall be installed such that the text is parallel with the axis of the conduit. The label shall be oriented such that the text can be read without the use of any special tools or removal of equipment.
  5. Labels shall be installed after each conduit is installed and, if applicable, after painting. Labels shall be printed in the field via the use of a portable label printing system. Handwritten labels are not acceptable.
  6. Labels shall be made of permanent vinyl with adhesive backing. Labels made of any other material are not acceptable.



- B. Conduits that are not exposed but installed beneath free standing equipment enclosures shall be identified by means of a plastic tag with the following requirements:
  - 1. The tag shall be made of white Tyvek material, and have an orange label with black text, as described above, adhered to it. Text for the label shall be the conduit number as indicated in the conduit and wire schedules.
  - 2. The tag shall be affixed to the conduit by means of a nylon cable tie. The tag shall be of suitable dimensions to achieve a minimum text size of 18 points.
- C. Conduits for lighting and receptacle circuits shall not require identification.
- D. Any problems or conflicts with meeting the requirements above shall immediately be brought to the attention of the Engineer for a decision.

### **3.07 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. All conduit installed below grade or concrete encased shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of a suitable pulling rope.

### **3.08 TRAINING OF INSTALLATION PERSONNEL**

- A. All Contractor personnel that install PVC coated RGS conduit shall be trained by the PVC coated RGS conduit manufacturer. Training shall include proper conduit system assembly techniques, use of tools appropriate for coated conduit systems, and field bending/cutting/threading of coated conduit. Training shall have been completed within the past 24 months prior to the Notice to Proceed on this Contract to be considered valid. Contractor personnel not trained within this timeframe shall not be allowed to install coated conduit or shall be trained/re-trained as required prior to commencement of conduit installation.

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**SECTION 26 05 33.16**  
**BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The scope of work under this Section includes furnishing and installing all pull boxes, junction boxes, and outlet boxes.
- B. Requirements for other boxes and enclosures are not included in this Section. Reference each specific equipment Section for requirements related to that equipment's respective enclosure.
- C. Reference Section 26 05 00 – Basic Electrical Requirements, and Section 26 05 33.13 – Conduit for Electrical Systems.

**1.02 CODES AND STANDARDS**

- A. Boxes shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. UL 514A – Metallic Outlet Boxes
  - 2. UL 514C – Standard for Non-metallic Outlet Boxes, Flush Device Boxes, and Covers
  - 3. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations
  - 4. UL 50E – Enclosures for Electrical Equipment, Environmental Considerations
  - 5. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.
  - 6. NEMA 250 – Enclosures for Electrical Equipment

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:
  - 1. Shop Drawings
- B. Each submittal shall be identified by the applicable specification section.

#### **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible Submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
  - 1. Product data sheets for boxes, terminal strips, and all accessories

#### **1.05 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.
- B. As-built drawings showing dimensions, internal box layout, terminal strip information, and terminal strip identification information shall be provided for all junction boxes. As-built drawings are not required for pull boxes or outlet boxes.

#### **1.06 IDENTIFICATION**

- A. Each pull and junction box shall be identified with the box name as indicated on the Contract Drawings (e.g. PPB-XXX, CJB-YYY) or as directed by the Engineer. A nameplate shall be securely affixed in a conspicuous place on each box. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

### **PART 2 – PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

#### **2.02 PULL AND JUNCTION BOXES**

- A. General
  - 1. All pull and junction boxes shall be UL listed and labeled.
  - 2. Pull and junction boxes shall not be provided with eccentric or concentric knockouts.

3. Pull and junction boxes mounted embedded in concrete shall be UL listed for embedment.
4. Where metallic boxes are used, they shall be of all welded construction. Tack welded boxes are not acceptable.

#### B. Pull Boxes

1. All pull boxes shall be provided with a matching gasketed cover. For covers with dimensions of 24 inches by 24 inches or less, the cover shall be held in place by machine screws. Other screw types are not acceptable. For covers with dimensions greater than 24 inches by 24 inches, the cover shall be hinged and held in place by screw-operated clamp mechanisms. Hinge pins shall be removable. Clamp mechanism material of construction shall match that of the associated box.
2. Pull boxes shall not have any wire terminations inside, other than those for grounding/bonding. A ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the pull box (minimum of two) shall be provided as spare terminations. Boxes requiring any other wire terminations shall be furnished and installed in accordance with the requirements for junction boxes herein.
3. Pull boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC.
4. Barriers shall be provided in pull boxes to isolate conductors of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:
  - a. Power wiring
  - b. AC control wiring
  - c. DC control wiring
  - d. Instrumentation wiring

#### C. Junction Boxes

1. Junction boxes used for lighting and receptacle circuits only shall be provided with a matching gasketed cover held in place by machine screws. Other screw types are not acceptable.
2. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with a hinged, gasketed cover. Hinge pins shall be removable. Cover

shall be held in place by screw-operated clamp mechanisms. Clamp mechanism material of construction shall match that of the associated box.

3. Barriers shall be provided in junction boxes to isolate conductors and terminal blocks of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:
  - a. Power wiring
  - b. AC control wiring
  - c. DC control wiring
  - d. Instrumentation wiring
4. Junction boxes used for lighting and receptacle circuits only shall be allowed to have screw-on (wire nut) type connectors for wire terminations/junctions.
5. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with terminal strips, consisting the necessary number of screw type terminals. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected, with a 10A minimum capacity. Terminal strips shall be rated for the voltage of the circuits connected. A separate ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the junction box (minimum of two) shall be provided as spare terminations. When barriers are provided within the box, separate terminal strips shall be provided in each barrier area. Terminals shall be lettered and/or numbered to conform to the wiring labeling scheme in place on the project.
6. Junction boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC. Terminal blocks (including spare terminals) shall be considered when sizing the junction box.

#### D. Enclosure Types and Materials

1. In non-hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

<b>Area Designation</b>	<b>Enclosure Type and Material</b>
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2. In hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

<b>Area Classification</b>	<b>Enclosure Type and Material</b>
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Type 304 Stainless Steel
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 4X, Type 304 Stainless Steel

3. Non-metallic enclosures, NEMA 7 enclosures, and NEMA 9 enclosures shall be provided with threaded integral conduit hubs.

## **2.03 OUTLET BOXES**

### **A. General**

1. Outlet boxes shall be provided with a trim appropriate for the wiring device installed inside. Reference Section 26 27 26 – Wiring Devices, for outlet box trim requirements. An appropriate outlet box trim is required to achieve the NEMA rating of the outlet boxes as specified herein.

### **B. Surface Mount Outlet Boxes**

- Outlet boxes shall be the deep type, no less than 2.5 inches deep.
- Outlet boxes shall be provided in single or multi-gang configuration as required, sized in accordance with the requirements of the NEC.
- In non-hazardous locations, outlet boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the

Drawings.

<b>Area Designation</b>	<b>Enclosure Type and Material</b>
Indoor Wet Process Area	NEMA 4X, Cast Aluminum
Indoor Dry Process Area	NEMA 1, Cast Aluminum
Indoor Dry Non-process Area	NEMA 1, Cast Aluminum
All Outdoor Areas	NEMA 4X, Cast Aluminum

- In hazardous locations, outlet boxes shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

<b>Area Classification</b>	<b>Enclosure Type and Material</b>
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Cast Aluminum
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 4X, Cast Aluminum

- Outlet boxes shall be provided with integral threaded conduit hubs mounted external to the box. Boxes with threaded conduit hubs mounted internal to the box or as a part of the box wall are not acceptable.

C. Flush Mount Outlet Boxes

- Outlet boxes shall be no less than 2-1/8 inches deep, and 4-11/16 inches square. Boxes shall be UL listed and labeled. Pre-punched single diameter conduit knockouts are acceptable; however, concentric and eccentric knockouts are not acceptable.
- Outlet boxes mounted flush in CMU walls shall be made of galvanized, tack welded steel, and suitable for installation in masonry walls. Sectional type boxes are not acceptable for this application.
- Outlet boxes mounted flush in gypsum walls shall be made of galvanized pressed steel. Tack welded boxes are not acceptable for this application. Sectional type boxes are not acceptable for this application.
- Outlet boxes mounted cast into concrete shall be concrete tight and made of galvanized steel or PVC.



## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

#### **A. Pull and Junction Boxes**

1. Pull boxes and junction boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.
2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.
3. Box penetrations for conduits shall be made with a punch tool, and penetrations shall be of the size required for the conduit entry and/or hub. Oversized penetrations in boxes are not acceptable.
4. Watertight conduit hubs shall be provided for boxes where a NEMA 4X enclosure rating is specified. Reference Section 26 05 33.13 – Conduit for Electrical Systems for conduit hub requirements.
5. Pull and junction boxes may be installed flush mounted in gypsum, concrete or CMU walls where appropriate provided that covers are easily removed or opened.
6. Pull and junction boxes shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

#### **B. Outlet Boxes**

1. Outlet boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.
2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.
3. Flush mounted outlet boxes shall be arranged and located so that tile and grout lines fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.
4. Outlet boxes shall be flush mounted in finished areas and other areas where practical. Flush mounted outlet boxes shall not be installed in hazardous areas and type 1 or 2 chemical storage/transfer areas.

5. For the below-named items, mounting heights from finished floor, or finished grade to top is applicable, depending on the type of wiring device to be installed in the outlet box. Mounting heights for outlet boxes shall be as follows, unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):
  - a. Light switches and wall mounted occupancy sensors, 48 inches
  - b. Receptacles in indoor dry process/non-process areas, 16 inches
  - c. Receptacles in indoor wet process areas and all indoor chemical storage/transfer areas, 48 inches
  - d. Receptacles in outdoor locations, 24 inches
  - e. Ceiling mounted occupancy sensors, as indicated on the Drawings
6. Outlet boxes shall be provided in the material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

**END OF SECTION**

**SECTION 26 05 53**  
**IDENTIFICATION FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All switchgear, switchboards, motor control centers, variable frequency drives, lighting and distribution panelboards, combination starters, control panels, pull and junction boxes, enclosures, disconnect switches, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.
- B. The types of electrical identification specified in this section include, but are not limited to, the following:
  - 1. Operational instructions and warnings.
  - 2. Danger signs.
  - 3. Equipment/system identification signs.
  - 4. Nameplates.

**1.02 SIGNS**

- A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.

**1.03 LETTERING AND GRAPHICS**

- A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

**1.04 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

**1.05 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
  - 1. Product data sheets.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

### **2.02 NAMEPLATES**

- A. Nameplates shall be engraved, high pressure plastic laminate, white with black lettering.
- B. Nameplates shall be attached to NEMA 4X enclosures utilizing UL-recognized mounting kits designed to maintain the overall UL Type rating of the enclosure. Mounting kit fasteners shall be stainless steel Type AHK10324X as manufactured by Hoffman, or equal.

### **2.03 HIGH VOLTAGE SIGNS**

- A. Standard "DANGER" signs shall be of baked enamel finish on 20 gage steel; of standard red, black and white graphics; 14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate identification.

### **2.04 CONDUIT IDENTIFICATION**

- A. Conduit identification shall be as specified in Section 26 05 33.13 – Conduit for Electrical Systems.

## **2.05 WIRE AND CABLE IDENTIFICATION**

- A. Field installed wire and cable identification shall be as specified in Section 26 05 19 – Low Voltage Conductors and Cable.
- B. A plastic laminate nameplate shall be provided at each panelboard, motor control center, switchgear assembly, and switchboard assembly. This nameplate shall be used to clearly convey the conductor identification means used at that piece of equipment (i.e. Phase A=Brown, Phase B=Orange, C = Yellow).
- C. Wiring identification for factory installed wiring in equipment enclosures shall be as specified in the respective section.

## **2.06 BOX IDENTIFICATION**

- A. Pull, junction and device box identification shall be as specified in Section 26 05 33.16 – Boxes for Electrical Systems.

## **PART 3 – EXECUTION**

### **3.01 NAMEPLATES**

- A. Nameplates shall be attached to the equipment enclosures with (2) two stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives is not permitted.

### **3.02 OPERATIONAL IDENTIFICATION AND WARNINGS**

- A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

### **3.03 POWER SOURCE IDENTIFICATION**

- A. After installation of all field equipment (i.e. valves, motors, fans, unit heaters, instruments, etc) install nameplates at each power termination for the field equipment. Nameplate data shall include equipment designation (tag number), power source (MCC number, panelboard, etc), circuit number, conduit number from schedule and voltage/phase.

- B. Contractor to coordinate with the Engineer and the Owner regarding exact nameplate placement during construction.
- C. Nameplates shall be as specified herein.

**END OF SECTION**

**SECTION 26 05 60**  
**LOW-VOLTAGE ELECTRIC MOTORS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all low voltage electric motors as shown on the Drawings and specified herein. All motors required for this Contract shall comply with this Section unless otherwise noted.

**1.02 CODES AND STANDARDS**

- A. Motors and related accessories shall be designed, manufactured, and/or listed to the following standards as applicable:
1. Institute of Electrical and Electronics Engineers (IEEE)
    - a. IEEE 112 – Standard Test Procedure for Polyphase Induction Motors and Generators
  2. National Electrical Manufacturer's Association (NEMA)
    - a. NEMA MG 1 – Motors and Generators
  3. Underwriters Laboratories (UL)
    - a. UL 547 – Standard for Safety Thermal Protectors for Motors
    - b. UL 674 – Electric Motors and Generators for Use in Hazardous (Classified) Locations
    - c. UL 1004-1 – Standard for Rotating Electrical Machines
    - d. UL 1004-3 – Standard for Thermally Protected Motors
    - e. UL 1004-8 – Standard for Inverter Duty Motors

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
1. Shop Drawings.

2. Spare Parts List.

B. Each submittal shall be identified by the applicable specification section.

#### **1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Individual shop drawings for electric motors shall be submitted in accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittals, unless submitted as a part of the shop drawings for the driven equipment.

D. Shop drawings for electric motors shall include motor data sheets, dimensioned drawings, wiring diagrams for devices such as space heaters, temperature devices, and shaft grounding rings. Shop drawings shall identify electric characteristics and design, mechanical construction, manufacturer's name, type and pertinent specifications for the use intended, along with the name of the equipment to be driven. For motors rated 50 horsepower or greater, submittal of motor data for acceptance shall include, as a minimum, the following:

1. Manufacturer's type and frame designation
2. Horsepower rating
3. Time rating (per NEMA Standards)
4. Ambient temperature rating
5. Motor winding insulation system designation
6. RPM at rated load
7. Frequency
8. Number of phases
9. Rated-load amperes
10. Voltage
11. Code letter (starting KVA per horsepower)
12. Design letter for integral horsepower induction motors (per NEMA Standards)



13. Service factor
  14. Temperature rise at full load and at service factor load
  15. Efficiency at 1/4, 1/2, 3/4 and full load
  16. Power factor at 1/4, 1/2, 3/4 and full load
  17. Motor outline, dimensions and weight
  18. Motor winding insulation system description
  19. Horsepower required by connected machine at specified conditions (load curves) shall be supplied for all compressors, propeller and positive displacement pumps.
  20. The foregoing data shall also be verified after manufacture and shall be included with the information to be furnished in the operation and maintenance manuals specified.
- E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

#### **1.05 SPARE PARTS**

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

### **PART 2 – PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. Electric motors shall be manufactured by Baldor/Reliance Electric Company; Nidec Motors; Toshiba Industrial and Power Systems, Inc.; Siemens Energy & Automation, Inc.; General Electric Company; or equal.

#### **2.02 MATERIALS AND CONSTRUCTION**

- A. Motors shall be built in accordance with the latest standards of NEMA, including, but not limited to MG-1 and MG-2, IEEE, ANSI and to the requirements specified herein.

## B. Type

1. Unless otherwise noted, motors specified herein shall be polyphase squirrel cage, NEMA Design B, or single phase capacitor or repulsion start induction motors. Special equipment requiring a motor drive with unusual characteristics shall be equipped with a definite purpose motor to meet the necessary requirements.
2. Unless otherwise shown or specified, all motors 1/2 horsepower or larger shall be three- phase, 60 Hertz, NEMA Design B, squirrel cage induction motors designed for operation at 480 volts or greater as specified herein or shown on the Drawings.
3. Unless otherwise specified in the individual equipment specification for the driven equipment, or as required by the dynamic characteristics of the load as determined by the manufacturer of the machine to be driven, all polyphase squirrel cage motors shall be designed to withstand the starting voltage shown on the Drawings and shall have torque and locked rotor current characteristics as specified for NEMA Design B motors.
4. All motors 2 horsepower and smaller shall have windings encapsulated with a flexible epoxy compound, or insulated with a flexible epoxy compound, or insulated with the manufacturer's premium quality system which shall be subject to acceptance by the Engineer.
5. All motors above 250 horsepower shall have stator windings vacuum impregnated with a polyester insulation compound.
6. Unless otherwise noted, all motors smaller than 1/2 horsepower shall be standard single-phase capacitor start or repulsion start induction type designed for operation on 120 volts or 208 volts, 60 Hz alternating current. The motor shall deliver rated load without exceeding a 80 degrees C temperature rise while operating in a 40 degrees C ambient temperature. Small fan motors less than 1/4 HP may be split-phase or shaded pole type. Shaded pole motors rated more than 1/4 horsepower are not acceptable. Fractional horsepower motors shall be completely equipped with all necessary auxiliary components for starting and labeled as "Thermally Protected". Insulation shall be Class B, except that submersible motors shall have epoxy encapsulation. Unless otherwise noted, the motors shall be totally enclosed. Small fan motors may be of the open type where they are suitably protected from moisture dripping and lint accumulation. Motors shall be provided with sealed ball bearings lubricated for 10 years of normal use.
7. Where specified, vertical hollowshaft motors shall be designed to carry the motors', pumps', and associated equipment's full thrust. The motors shall be equipped with grease lubricated spherical roller thrust bearings and lower radial guide bearings. Vertical hollowshaft motors shall be fitted with nonreversing ratchet assemblies where required by equipment specifications. Vertical adjustment shall be provided by means of a lockable nut at the top of the shaft.

8. Vertical hollowshaft motors shall have adequate thrust bearings to carry all motor loads and any other operating equipment loads. Horizontal motors shall not be installed where subjected to external thrust loads.

#### C. Rating

1. Each motor shall develop ample torque for its required service through its acceleration range and throughout its rated load range. The rating of the motors offered shall in no case be less than the horsepower shown on the Drawings or elsewhere specified. It should be noted that the motor sizes indicated on the Drawings or as otherwise specified herein, are motor sizes required to operate the specific equipment which is specified. Higher rated motor sizes may be determined from the actual equipment submitted, approved, purchased, and installed. Protective devices, motor starters, disconnect switches, and other necessary equipment shall be furnished and installed for the actual motor sizes required at no additional cost.
2. Motor ratings shall be based on continuous operation. The maximum temperature rise for open and drip proof type motors shall not exceed 90 degrees C, and for totally enclosed type motors shall not exceed 80 degrees C.

#### D. Motor Winding Insulation

1. Insulation shall be as specified for each particular type or class of motor. The insulation system shall provide a high dielectric strength, long life covering for the windings which may be required to operate in a continually damp, corrosive, and/or chemically contaminated environment. The insulation shall be resistant to attack by moisture, acids, alkalies, abrasives, and mechanical and thermal shock. Leads shall be sealed with a non-wicking, non-hydroscopic insulation material.
2. Motor insulation resistance may be checked at any time after delivery to the job site or during the warranty period. Encapsulated motor stators may be subjected to insulation testing while completely submerged in water. Any motor not meeting the requirements specified herein will be rejected and shall be promptly replaced at no cost to the Owner.
3. Torque and locked rotor current characteristics for three phase motors shall be NEMA Design B. The locked rotor KVA/HP input at full voltage for 10 horsepower. motors and larger shall not exceed that permitted for Code Letter "J", except for specialized equipment requiring a motor drive with special definite characteristics.
4. Unless otherwise specified, non-inverter duty motors shall be furnished with a Class F insulation system. Unless otherwise specified, inverter duty motors shall be furnished with a Class H insulation system. In either case, temperature rise shall be limited to that for Class B insulation. Output torque and speed characteristics of each motor shall be suitable to operate the driven equipment

through the full range of acceleration and operating load conditions without exceeding the nameplate current rating, and/or temperature rise.

E. Nameplates

1. The motor manufacturer's nameplate shall be engraved, embossed, or stamped on a stainless steel sheet and fastened to the motor frame with No. 4 or larger oval head stainless steel screws or drive pins. Printed or laser-etched nameplates are not acceptable.
2. Nameplates shall include as a minimum, Items a through m as listed in Article 1.04 in addition to that required by NEMA standards. The nameplate shall be positioned so as to be readily visible for inspection as installed in the facility.

F. Design

1. Motors shall be designed to accelerate and drive the connected equipment under all normal operating conditions without exceeding nameplate ratings.
2. Motors specified for operation with variable frequency drives shall be inverter duty rated. Motors shall be considered inverter duty rated only if they meet all of the requirements for NEMA MG-1 Part 31.
3. Motors shall be designed to output 100 percent of nameplate horsepower under continuous duty service without exceeding the temperature rise specified herein when controlled by the actual drives furnished. Inverter duty motors shall be designed to operate down to 10% of full load speed without the need for a line powered cooling fan.
4. Unless otherwise specified, electric motors shall be furnished with service factors in accordance with NEMA MG-1 as follows:

Type of Motor	Service Factor
Non-inverter Duty	1.15
Inverter Duty	1.0

5. Design selection with respect to the driven machine shall be such that the requirements do not exceed 85 percent of the motors' maximum rating modified by service factor, ambient temperature, enclosure, altitude and electrical service. The electrical service conditions shall be assumed to be 10 percent undervoltage, 5 percent underfrequency, and 3 percent voltage unbalance. Altitude shall be assumed to be the project site elevation plus 10 percent. Ambient temperature shall be assumed to be 95 degrees F in exterior locations, 104 degrees F (40 degrees C) in interior locations, and 122 degrees F (50 degrees C) within housings or enclosures; except where higher temperatures may be encountered within or on

individual items of equipment. The applicable paragraphs of NEMA MG-1 shall be used in making the design selection.

6. Motors used with belt drives shall have sliding bases to provide for belt take up.
7. Terminal boxes shall be of sufficient size to accommodate the required quantity and size of conduits. Gasketed terminal boxes shall be furnished with all splash-proof and totally enclosed motors. NEMA ratings of the terminal boxes shall be suited for the application. Motors located in hazardous locations shall be furnished with terminal boxes suitable for the specific Class, Division, and Group suitable for the application. Terminal boxes shall be sized to accommodate accessory equipment such as motor differential current transformers, where required.
8. Terminal boxes for horizontal motors shall be located on the left-hand side when viewing the motor from the drive shaft end and shall be so designed that conduit entrance can be made from above, below, or either side of the terminal box.
9. Motors larger than 250hp shall be manufactured with the six stator coil leads wired to a suitably sized motor junction box for application in a differential relay scheme. Current transformers shall be provided by the motor manufacturer and installed in the factory. All ground connections and current transformer connections shall be made in the factory.

#### G. Construction

1. Frames, mounting means, and shafts shall meet NEMA Standards for the horsepower, RPM, and enclosure selected. Enclosures shall be selected according to the degree of mechanical protection required and shall not be of aluminum construction. All motors shall have a manufacturer's standard shop machinery finish, consisting of a rust-resisting priming coat of zinc chromate and a finish coat of alkyd machinery enamel.
2. Motors shall have cast iron frames and a heavy gauge steel terminal box, with neoprene gaskets between the frame and the box and between the box and its cover. A grounding lug(s) shall be provided inside the terminal box.
3. Motors weighing more than 50 pounds shall be equipped with at least one lifting eye. All lifting hardware shall be corrosion resistant.
4. Motors located in hazardous locations shall be totally enclosed and suitable for the specific Class, Division, and Group suitable for the application.
5. Motors located in Class I or II, Division 1 hazardous locations shall bear a U.L.-674 label and shall be provided with a breather/drain approved for the hazardous location. The U.L. listed breather/drain shall prevent the entrance of contaminants while allowing moisture to drain out of the motor.

6. When located outdoors, or elsewhere if specified, motors shall be totally enclosed, non-ventilated (TENV) or totally enclosed, fan-cooled (TEFC) machines, unless otherwise noted. Totally enclosed motors shall be provided with two (2) 1/4 inch drain holes drilled through the bottom of the frame, which allows complete drainage of the frame. Where specified, TEFC motors controlled by a variable frequency drive shall be provided with a separately powered cooling fan motor that runs at 60HZ to ensure proper cooling of the motor at low speeds. Cooling fan motor shall be suitable for 120VAC, single phase operation. Vertically oriented motors located outdoors shall be provided with a drip cover over the fan end to prevent accumulation of precipitation.
7. Unless otherwise specified, motors rated 100 horsepower or greater located outdoors, in unheated structures, in below grade areas, or as otherwise indicated, shall be furnished with space heaters and embedded motor winding high temperature switches with leads brought out of the motor terminal box. Space heaters shall be suitable for 120VAC operation and for a maximum surface temperature of less than 200 degrees C. Spare heaters shall be of sufficient wattage to maintain the internal temperature of the motor at approximately 10 degrees C above the ambient temperature when the motor is not running.
  - a. Embedded motor winding temperature switches shall operate at temperatures well below the temperature rating of the motor winding insulation system. Motor winding temperature switches are not required where other temperature monitoring devices (e.g. RTD's) are required.
8. Unless otherwise specified in the equipment specifications, motors rated 200HP or greater that are controlled by a VFD shall be furnished with resistance thermal detectors (RTD's) embedded in the stator windings, two per phase. RTD's shall be pre-wired to terminal blocks located in a separate terminal box as specified herein.
9. Unless otherwise specified in the equipment specifications, motors rated less than 200HP that are controlled by a VFD shall be furnished with motor winding high temperature switches embedded in the stator windings with the leads brought out to the motor terminal box.
10. If so specified and when located in indoor areas which are heated and weatherproof, motors shall be open drip-proof machines. Ventilation openings shall be arranged to prevent the entrance of drops of liquid or solid particles at any angle from zero to 15 degrees downward from vertical.
11. Unless otherwise specified, or required, motors rated less than 200 horsepower shall be furnished with bearings of the grease lubricated, antifriction ball type with conveniently located grease fittings and drain plugs. A means of preventing bearings from becoming over-greased shall be provided. Bearings shall have a minimum B-10 life of 20,000 hours.

12. Rotors shall be statically and dynamically balanced. Rotor windings shall be one-piece cast aluminum. Where applicable, rotors shall be constructed with integral fins.
13. Externally mounted motor shaft grounding rings shall be provided to protect motors against motor shaft and bearing currents. Grounding rings shall be provided for all motors controlled by VFDs, with the following exceptions:
  - a. Motors located in hazardous areas
  - b. Motors rated less than 1 horsepower
  - c. Submersible motors
14. All motors shall be provided with factory-installed one-hole terminations (ring terminals) on the ends of all motor leads. Terminations shall be identified for use with cables that have stranding other than Class B and shall be the irreversible compression type.

#### H. Power Factor and Efficiency

1. All motors, including vertical hollowshaft motors, in the range of 1-500 horsepower, inclusive, shall be designed specifically for energy efficiency and high power factor. The motor efficiency and power factor shall meet or exceed the values listed in the table below when the motors are tested in accordance with the NEMA preferred test method IEEE 112A, Method B, Dynamometer. Each motor shall meet the minimum guaranteed efficiency value indicated in the table below. All tests shall be performed in accordance with the procedures contained in NEMA Standard MG1-12.58.

**Table 12-11  
FULL-LOAD EFFICIENCIES OF ENERGY EFFICIENT MOTORS  
ENCLOSED MOTORS**

HP	2 POLE		4 POLE		6 POLE		8 POLE	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	75.5	72	82.5	80	80	77	74	70
1.5	82.5	80	84	81.5	85.5	82.5	77	74
2	84	81.5	84	81.5	86.5	84	82.5	80
3	85.5	82.5	87.5	85.5	87.5	85.5	84	81.5
5	87.5	85.5	87.5	85.5	87.5	85.5	85.5	82.5
7.5	88.5	86.5	89.5	87.5	89.5	87.5	85.5	82.5
10	89.5	87.5	89.5	87.5	89.5	87.5	88.5	86.5
15	90.2	88.5	91	89.5	90.2	88.5	88.5	86.5
20	90.2	88.5	91	89.5	90.2	88.5	89.5	87.5
25	91	89.5	92.4	91	91.7	90.2	89.5	87.5
30	91	89.5	92.4	91	91.7	90.2	91	89.5
40	91.7	90.2	93	91.7	93	91.7	91	89.5
50	92.4	91	93	91.7	93	91.7	91.7	90.2
60	93	91.7	93.6	92.4	93.6	92.4	91.7	90.2
75	93	91.7	94.1	93	93.6	92.4	93	91.7
100	93.6	92.4	94.5	93.6	94.1	93	93	91.7
125	94.5	93.6	94.5	93.6	94.1	93	93.6	92.4
150	94.5	93.6	95	94.1	95	94.1	93.6	92.4
200	95	94.1	95	94.1	95	94.1	94.1	93
250	95.4	94.5	95	94.1	95	94.1	94.5	93.6
300	95.4	94.5	95.4	94.5	95	94.1		
350	95.4	94.5	95.4	94.5	95	94.1		
400	95.4	94.5	95.4	94.5				
450	95.4	94.5	95.4	94.5				
500	95.4	94.5	95.8	95				

**Table 12-12  
FULL-LOAD EFFICIENCIES FOR NEMA PREMIUM™ EFFICIENCY ELECTRIC MOTORS  
RATED 600 VOLTS OR LESS (RANDOM WOUND)  
OPEN MOTORS**

HP	2 POLE		4 POLE		6 POLE	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency



**Table 12-12  
FULL-LOAD EFFICIENCIES FOR NEMA PREMIUM™ EFFICIENCY ELECTRIC MOTORS  
RATED 600 VOLTS OR LESS (RANDOM WOUND)  
OPEN MOTORS**

HP	2 POLE		4 POLE		6 POLE	
	Nominal	Minimum	Nominal	Minimum	Nominal	Minimum
1	77	74	85.5	82.5	82.5	80
1.5	84	81.5	86.5	84	86.5	81.5
2	85.5	82.5	86.5	84	87.5	81.5
3	85.5	82.5	89.5	84	88.5	86.5
5	86.5	84	89.5	84	89.5	87.5
7.5	88.5	86.5	91	89.5	90.2	88.5
10	89.5	87.5	91.7	90.2	91.7	90.2
15	90.2	88.5	93	91.7	91.7	90.2
20	91	89.5	93	91.7	92.4	91
25	91.7	90.2	93.6	92.4	93	91.7
30	91.7	90.2	94.1	93	93.6	92.4
40	92.4	91	94.1	93	94.1	93
50	93	91.7	94.5	93.6	94.1	93
60	93.6	92.4	95	94.1	94.5	93.6
75	93.6	92.4	95	94.1	94.5	93.6
100	93.6	92.4	95.4	94.5	95	94.1
125	94.1	93	95.4	94.5	95	94.1
150	94.1	93	95.8	95	95.4	94.5
200	95	94.1	95.8	95	95.4	94.5
250	95	94.1	95.8	95	95.4	94.5
300	95.4	94.5	95.8	95	95.4	94.5
350	95.4	94.5	95.8	95	95.4	94.5
400	95.8	95	95.8	95	95.8	95
450	95.8	95	96.2	95.4	96.2	95.4
500	95.8	95	96.2	95.4	96.2	95.4

NOTES:

(Motor data for continuous duty, NEMA Design B, 1.15 service factor, 40 degrees Celsius ambient, Class F insulation, 3 phase, 460 volt, at listed speed rating.

(TEFC efficiencies apply to both horizontal and vertical motors.

2. Motors rated 50 horsepower or greater shall be individually tested at the factory before shipment, with a copy of test results provided for the Engineer, to assure compliance with the efficiency and power factor specifications.

- I. Power Factor Correction (Not Used)

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Motors shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

### **3.02 DELIVERY, STORAGE, AND HANDLING**

- A. Motors shall be properly protected from weather hazards. Motors shall not be allowed to be wrapped tightly in plastic while outdoors. Motors delivered to the site which will not be put in service for a time in excess of 30 calendar days, whether in storage or installed, shall have the shafts rotated a minimum of five (5) rotations every 30 days.
- B. Motors provided with space heaters shall have temporary power applied to the heaters no later than 30 calendar days after delivery to the site until permanent power can be applied to the heaters.
- C. Motors that, in the opinion of the Engineer, have not been properly protected shall be inspected by the manufacturer's representative. Any required electrical corrections for testing shall be made at the Contractor's expense prior to acceptance and/or use.
- D. All motors shall operate without any undue noise or vibration and shall show no signs of phase unbalance.

### **3.03 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. Witnessed Shop Tests
    - a. All motors shall be shop tested and inspected in accordance with the equipment manufacturer's standard procedures. Shop tests for motors 100 horsepower and larger may be witnessed by the Engineer. The manufacturer's testing and inspection procedures shall demonstrate that the equipment tested conforms to the requirements specified, all other applicable requirements, and shall be approved by the Engineer. At least 10 days' notice shall be given the Engineer prior to tests and inspection dates.
    - b. In addition to the efficiency and power factor testing specified herein, each motor shall be tested to determine compliance with the applicable requirements of the IEEE, ANSI and NEMA. Tests shall be as follows:
      - 1) Motors less than 50 HP:

- a) Each motor shall be subjected to a standard, short commercial test including the following:
  - Running current, no load
  - Locked rotor current
  - High potential
  - Winding resistance
  - Bearing inspection
- 2) Motors between 50 and 100 HP
  - a) Each motor shall be subjected to the above tests and shall be furnished with certified test results.
- 3) Motors larger than 100 HP
  - a) Each motor shall be furnished with certified test results. Each motor shall be subjected to a complete test consisting of full load heat run, percent slip, running load current, locked rotor current, breakdown torque (calculated), starting torque, winding resistance, high potential, secondary current and voltage at collector rings (wound rotor), efficiencies at 100, 75 and 50 percent of full load, power factors at 100, 75 and 50 percent of full load and bearing inspection. Tests will be witnessed by the Engineer where specifically indicated.
- 4) Test Reports
  - a) All test results for motors over 100 horsepower shall be submitted to the Engineer for approval. Copies of witnessed test raw data shall be submitted to the Engineer immediately upon completion of such tests.

## 2. Field Tests

- a. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 1, and Section 26 05 00 – Basic Electrical Requirements.
- b. All electric motors furnished for this project one (1) horsepower or larger shall have the information required in the following tabulation completed. See Exhibit "A" on following page.
- c. All field testing shall be witnessed by the Engineer.

(EXHIBIT A)

<b>MOTOR TEST RECORD</b>					
<b>Motor Identification Remarks</b>	<b>Location</b>	<b>Specified Horsepower</b>	<b>Nameplate Horsepower</b>	<b>Nameplate Amperage (FLA)</b>	<b>Measured Amperage Under Normal Operating Conditions</b>

**END OF SECTION**

**SECTION 26 09 16**  
**ELECTRIC CONTROLS AND RELAYS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.
- B. Electrical control and relay systems shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.
- C. Reference Section 26 05 00 – Basic Electrical Requirements and Section 26 05 53 – Identification for Electrical Systems.

**1.02 CODES AND STANDARDS**

- A. Products specified herein shall be in conformance with or listed to the following standards as applicable:
  - 1. NEMA 250 – Enclosures for Electrical Equipment
  - 2. UL 508A – Standard for Industrial Control Panels
  - 3. UL-1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.
  - 4. ANSI/ISA 12.12.01-2013 – Nonincendive Electrical Equipment for use in Class I and II, Division II Hazardous (Classified) locations.

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings
  - 2. Spare Parts List
- B. Each submittal shall be identified by the applicable specification section.

## **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
  - 1. Product data sheets.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

## **1.05 SPARE PARTS (NOT USED)**

## **PART 2 – PRODUCTS**

### **2.01 CONTROL COMPONENTS**

- A. Manufacturers
  - 1. Control components shall be manufactured by Eaton, The Square D Company, General Electric, Allen-Bradley, or Engineer approved equal.
- B. Pilot Devices
  - 1. General
    - a. All pilot devices shall be provided with a legend plate. Legend plates shall have a white background and black lettering and indicate the function of the respective pilot device. The text shown on the Drawings or indicated in the specifications shall be used as the basis for legend plate engraving (i.e. HAND-OFF-AUTO, RUN, EMERGENCY STOP, etc.).
    - b. All pilot devices shall be selected and properly installed to maintain the NEMA 250 rating of the enclosure in which they are installed. All pilot devices shall be UL 508 Listed.
    - c. All pilot devices shall be 30.5mm in diameter, unless otherwise indicated. 22mm devices are not acceptable.

- d. Pilot devices for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.
- e. In Class 1 Division 2 hazardous locations, pilot devices shall be the hermetically-sealed type, constructed in accordance with ANSI/ISA 12.12.01.

## 2. Pushbuttons

- a. Pushbuttons shall be non-illuminated, black in color, and have momentary style operation unless otherwise indicated on the Drawings.
- b. Pushbuttons shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each pushbutton. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.
- c. Pushbuttons shall be provided with a full guard around the perimeter of the button. Where a lockout style pushbutton is specified or indicated on the Drawings, provide a padlockable guard.

## 3. Selector Switches

- a. Selector switches shall be non-illuminated, black in color, and have the number of maintained positions as indicated on the Drawings and as required. Handles shall be the extended type that provide a greater surface area for operation.
- b. Selector switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each selector switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.
- c. Where indicated in the Drawings or Specifications, provide spring return positions.
- d. Selector switches shall be provided with an indexing component that fits into the keyed portion of the cutout for the device and prevents the switch from spinning when operated.

## 4. Indicating Lights

- a. Indicating lights shall be LED type, with the proper voltage rating to suit the application, and push-to-test feature.
- b. Indicating light lens colors shall be as required in equipment specifications and/or as indicated on the Drawings. If lens colors are not indicated, the following colors shall be used:

Color	Designation
Red	"Run", "On", "Open"
Green	"Off", "Closed"
Amber	"Alarm", "Fail"
White	"Control Power On"

5. Emergency Stop and Tagline Switches

- a. Emergency stop switches shall be non-illuminated, red in color, with a minimum 35mm diameter mushroom head. Once activated, switch shall maintain its position and require a manual pull to release/reset.
- b. Tagline switches shall have a plunger that activates upon tension from the associated safety cable. Once activated, switch shall maintain its position and require a manual release/reset.
- c. Emergency stop and tagline switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

C. Relays and Timers

1. General

- a. Relays and timers shall be furnished with an integral pilot light for positive indication of coil energization.
- b. Relays and timers shall have tubular pin style terminals with matching 11-pin DIN rail mount socket. Spade or blade style terminals are not acceptable.
- c. Relays and timers for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.



## 2. Control and Pilot Relays

- a. Relays shall have a clear or translucent housing that allows the contacts to be visually inspected without disassembly.
- b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.
- c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have 3-pole, double-throw (3PDT) contact arrangement.

## 3. Time Delay Relays

- a. Timers delay relays shall utilize electronic timing technology. Mechanical timing devices are not acceptable.
- b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.
- c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have double-pole double-throw (DPDT) contact arrangement.
- d. Time delay ranges shall be as indicated on the Drawings and/or as required to suit the application. Timing range shall be adjustable from the front of the relay. On delay and off delay timer configurations shall be provided as indicated on the Drawings and/or as required to suit the application.

## 4. Elapsed Time Meters

- a. Elapsed time meters shall be non-resettable type with no less than a 4 digit display. Coil voltage shall be as required to suit the application and/or as indicated on the Drawings.

## D. Control Terminal Blocks

1. Control terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or subpanel. Terminals shall be tubular screw type with pressure plate that will accommodate wire size range of #22 – #8 AWG.
2. Control terminal blocks shall be single tier with a minimum rating of 600 volts and 20A. Separate terminal strips shall be provided for each type of control used (i.e. 120VAC vs. 24VDC). Quantity of terminals shall be provided as required to suit the application. In addition, there shall be a sufficient quantity of terminals for the termination of all spare conductors.

3. Terminals shall be marked with a permanent, continuous marking strip, with each terminal numbered. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal.

## 2.02 LOCAL CONTROL STATIONS

- A. Local control stations shall be furnished and installed complete with pushbuttons, selector switches, indicating lights, and other devices as indicated on the Drawings.
- B. Specific devices installed in local control stations shall be provided in accordance with the requirements specified elsewhere in this Section.
- C. In non-hazardous locations, local control stations shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Die Cast Zinc
Indoor Dry Non-process Area	NEMA 12, Die Cast Zinc
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

- D. In hazardous locations, local control stations shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

Area Classification	Enclosure Type and Material
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Type 304 Stainless Steel
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 9, Die Cast Aluminum

- E. Non-metallic enclosures, NEMA 7 enclosures, and NEMA 9 enclosures shall be provided with threaded integral conduit hubs. Conduit hubs shall be external to the enclosure.
- F. Local control stations for use in non-hazardous locations shall be UL-508 Listed. Local control stations for use in Class 1 Division 1 and Class 2 Divisions 1/2 hazardous

locations shall be UL-1203 Listed. Local control stations for use in Class 1 Division 2 hazardous locations shall be in accordance with ANSI/ISA 12.12.01-2013.

- G. Provide a nameplate on each local control station in accordance with Section 26 05 53 – Identification for Electrical Systems. The name and/or number of the equipment associated with each control station shall be engraved on the nameplate, followed by the words “LOCAL CONTROL STATION”.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Local control stations shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.
- B. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries' standard practices.
- C. Pilot devices shall be properly bonded to the equipment enclosure door where they are installed. If proper bonding cannot be achieved through the locknuts that affix the device in place, a green colored bonding screw shall be provided on the pilot device. The bonding screw shall be bonded to the equipment enclosure through the use of an insulated green bonding conductor.
- D. Local control station covers shall be bonded to the local control station enclosure through the use of an insulated green bonding conductor.
- E. Wiring to devices at each local control station shall be provided with enough slack to permit the local control station cover to be removed and pulled at least 6 inches away from the enclosure.
- F. Terminal strips, relays, timers, and similar devices shall not be installed on the rear of the panel/cabinet doors. Terminal strips, relays, timers, and similar devices shall not be installed on the side walls of panel/cabinet interiors without written permission from the Engineer.

**END OF SECTION**

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**SECTION 26 22 00**  
**LOW-VOLTAGE TRANSFORMERS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, and test transformers for power and lighting distribution systems as specified herein, as indicated on the Drawings, and as required to complete the electrical installations.
- B. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.
- C. Reference Section 26 05 00 – Basic Electrical Requirements.

**1.02 CODES AND STANDARDS**

- A. Transformers shall conform to all applicable Federal, UL, and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.
- B. Transformers shall comply with the following standards:
  - 1. UL 1561 – Dry Type General Purpose and Power Transformers
  - 2. U.S. Department of Energy 2016 Efficiency
  - 3. National Electrical Code
  - 4. NEMA ST-20 – Dry Type Transformers for General Applications
  - 5. ANSI C57 – Standard General Requirements for Dry Type Distribution and Power Transformers

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Division 1, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings.
  - 2. Operation and Maintenance Manuals.

3. Spare Parts List.
  4. Reports of Certified Shop Field Tests.
- B. Each submittal shall be identified by the applicable specification section.

#### **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein, and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
1. Product data sheets.
  2. Drawings showing clearly marked dimensions and weight for each transformer.
  3. Sample equipment nameplate diagram.
- D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g. TX-LP-BB).
- E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

#### **1.05 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

#### **1.06 SPARE PARTS**

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.
- B. Spare parts lists, included with the Shop Drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

- C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

## **1.07 IDENTIFICATION**

- A. Each transformer shall be identified with the equipment item number indicated on the Contract Drawings and the accepted Shop Drawings. A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. Dry type distribution transformers shall be Energy Star compliant and manufactured by the Square D Company, or the General Electric Company, Eaton.

### **2.02 DRY TYPE TRANSFORMERS**

- A. Furnish and install single-phase and three-phase general purpose, dry-type transformers, as specified herein and indicated on the Drawings. The transformers shall be 60 Hz, self-cooled, quiet-design insulated of the two-winding type.
- B. The transformers shall be UL 1561 Listed.
- C. The primary windings shall be rated 480 VAC for use on 3-phase systems and connected delta unless indicated otherwise on the Drawings. KVA ratings shall be as shown on the Drawings. Furnish transformers with two 2-1/2% primary taps above, and four 2-1/2% primary taps below rated voltage for transformers 15 KVA and above, and two 2-1/2% primary taps above, and two 2-1/2% primary taps below rated voltage for transformers less than 15 kVA. All taps shall be full capacity rated.
- D. The ratings of the secondary windings shall be as indicated on the Drawings.
- E. Transformers shall be designed for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in IEEE 65 and ANSI C57.96. This performance shall be obtainable without exceeding 150 degrees Celsius average temperature rise by resistance or 180 degrees Celsius hot spot temperature rise in a 40 degrees Celsius maximum ambient and 30 degrees Celsius average ambient. The maximum coil hot spot temperature shall not exceed 220 degrees Celsius. All insulating

materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D 635. All insulating materials shall be in accordance with NEMA ST 20 Standard for a 220 degrees Celsius UL component recognized insulation system.

- F. Transformer coils shall be of the continuous wound copper construction and shall be impregnated with non-hygroscopic, thermosetting varnish.
- G. All cores are to be constructed of high grade, non-aging, grain-oriented silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be tightly clamped and compressed with structural steel angles. The completed core and coil shall then be bolted to the base by means of vibration-absorbing mounts to minimize sound transmission. There shall be no metal-to-metal contact between the core and coil assembly and the enclosure.
- H. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees Celsius. Transformers shall be furnished with lugs of the size and quantity required and suitable for termination of the field wiring.
- I. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.
- J. Transformers shall have core and coil assemblies mounted on rubber isolation pads to minimize the sound levels. Transformers shall not exceed the sound levels listed in NEMA ST-20.
- K. Transformers shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 3R, Painted Steel
Indoor Dry Process Area	NEMA 2, Painted Steel
Indoor Dry Non-Process Area	NEMA 2, Painted Steel
All Outdoor Areas	NEMA 3R, Painted Steel

- L. The enclosure shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with a baked weather-resistant enamel using the manufacturer's standard painting process. Color shall be ANSI 61.

**2.03 DRIVE ISOLATION TRANSFORMERS (NOT USED)**



## **2.04 ISOLATION TRANSFORMERS (NOT USED)**

### **PART 3 – EXECUTION**

#### **3.01 INSTALLATION**

- A. The transformers shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer. Transformers provided as integral components of motor control centers shall be installed as recommended by the motor control center manufacturer.
- B. Conduit routed to and from the transformer shall be arranged for easy removal of the transformer access covers.
- C. Where transformers 50 kVA and smaller are shown to be wall mounted, a transformer manufacturer supplied wall mounting kit shall be used. The lowest point of the wall mounting bracket shall be no lower than 7'-0" above the finished floor. Field fabricated mounting hardware is not acceptable unless reviewed and approved in writing by the Engineer.
- D. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

#### **3.02 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. Certified Shop Tests
    - a. The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards. Temperature rises may be certified from basic design.
    - b. As a minimum, the following tests shall be made on all transformers:
      - 1) Ratio tests on the rated voltage connection and on all tap connections.
      - 2) Polarity and phase-relation tests on the rated voltage connection.
      - 3) Applied potential tests.
      - 4) Induced potential tests.
      - 5) No-load and excitation current at rated voltage on the rated voltage connection.

2. Field Tests

- a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.
- b. Insulation between windings shall be tested by 1000 VDC Megaohmmeter for one (1) minute. Resistance value shall be no less than 100 Megaohms.

**END OF SECTION**

**SECTION 26 24 16**  
**PANELBOARDS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install panelboards of voltage and current ratings as specified herein and indicated on the Drawings. Panelboards shall be furnished with circuit breaker ratings, number of breakers, number of poles and locations conforming to the panelboard schedules on the Drawings.
- B. Reference Section 26 05 00 – Basic Electrical Requirements; and Section 26 05 53 – Identification for Electrical Systems.

**1.02 CODES AND STANDARDS**

- A. Panelboards shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. Underwriters Laboratories
    - a. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations
    - b. UL 67 – Standard for Panelboards
    - c. UL 489 – Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures
    - d. UL 943 – Ground Fault Circuit Interrupters
    - e. UL 1449 – Standard for Surge Protective Devices
  - 2. NEMA PB1 – Panelboards
  - 3. National Electrical Contractors Association (NECA) Standard 407 – Standard for Installing and Maintaining Panelboards

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings.

2. Spare Parts List.
3. Operation and Maintenance Manuals.
4. Reports of Field Tests.

B. Each submittal shall be identified by the applicable specification section.

#### **1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.
2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each panelboard.
3. Complete panelboard schedules indicating circuit designations as shown on the Drawings for each panelboard.
4. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g., LP-1, PP-2, etc.).

#### **1.05 OPERATIONS AND MAINTENANCE MANUALS**

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books and/or leaflets.
2. Recommended spare parts list.
3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process and during field installation.

## **1.06 SPARE PARTS**

- A. For each panelboard, the Contractor shall furnish to the Owner all spare parts as recommended by the equipment manufacturer. All spaces in the panelboards shall be furnished with a spare breaker as indicated in the panelboard schedules shown on the Drawings.
- B. Spare parts lists shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

## **1.07 IDENTIFICATION**

- A. Each panelboard shall be identified with the identification name/number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each panelboard. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

### **2.02 CONDUCTORS (MAIN BUS AND BRANCH CONNECTORS)**

- A. All main bus shall be copper sized in accordance with UL standards to limit the temperature rise on any current carrying part to a maximum of 50 degrees C above a maximum ambient temperature of 40 degrees C.

### **2.03 LIGHTING PANELBOARDS**

- A. General
  - 1. Lighting panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal-overload, branch circuit breakers. Panelboards shall be of the configuration and rating as specified herein and indicated on the Drawings. Panelboards shall be UL 67 Listed and shall be constructed to NEMA PB1 standards. Panelboards shall be service entrance rated where indicated on the Drawings.

2. Lighting panelboards shall be equipped with a main breaker or main lugs complete with branch circuit breakers, as indicated on the Drawings. The panelboards shall be suitable for flush or surface mounting.
3. Lighting panelboards shall be fully rated and shall have a minimum short circuit rating of 22,000 amperes symmetrical, unless otherwise indicated on the Drawings.
4. Lighting panelboards shall be Eaton Pow-R-Line Series, the Square D Company equivalent, or the General Electric Company equivalent.

#### B. Enclosures

1. Enclosures shall be UL 50 listed and have a NEMA rating as indicated on the Drawings. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet. Enclosures designated as NEMA 4X shall be constructed of 304 stainless steel. Enclosures with all other NEMA ratings shall be constructed of No. 12 U.S.S. code gauge galvanized steel, painted ANSI #61 light gray. The enclosure shall have wiring gutters on sides and shall be at least 5-3/4 inches deep.
2. The door shall be fastened to the enclosure with concealed hinges and shall be equipped with flush-type catches and locks. The Contractor shall equip cabinet doors exceeding 40 inches in height with vertical bolt three-point locking mechanism. All locks shall be keyed alike. The panelboard trim shall have a removable hinge assembly, in addition to the door hinge, that allows work inside the enclosure without the need to remove the trim.
3. The panelboard shall be provided with an information label. The information label shall include the panelboard designation, voltage, phase, wires, and bus rating.

#### C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1000 amperes per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide full flexibility of circuit arrangement.
2. Solid neutral bus bars are required and neutral bus ampacity shall be the same as the main bus bars unless otherwise noted. Ratings shall be in accordance with applicable standards.
3. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.

4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.
5. All bus shall be tin-plated copper and shall extend the entire useable length of the panelboard, including spaces.

#### D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type and UL 489 Listed. All circuit breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation. Tandem or half-size circuit breakers are not acceptable.
2. Ground Fault Circuit Interrupter (GFCI): Where indicated on the Drawings, or where required by Code, circuit breakers shall be equipped with integrally mounted ground fault interrupters complete with "TEST" push button and shall be of a type which fit standard panelboard spaces for the breaker continuous current rating required. Ground fault circuit interrupter style circuit breakers shall be UL 943 Listed.
3. Equipment Ground Fault Interrupter (EGFI): Where indicated on the Drawings, circuit breakers shall be equipped with integrally mounted ground fault interrupters that are rated to trip on a 30 milli-amp ground fault.
4. Circuit breakers used for lighting circuit switching shall be approved for the purpose and shall be marked "SWD". Where required by Article 440 of the NEC, circuit breakers installed for air conditioning units shall be HACR type.
5. Circuit breaker voltage ratings shall meet or exceed the panelboard voltage indicated on the Drawings. Trip elements of circuit breakers shall be 20A unless otherwise indicated on the Drawings. Circuit breakers shall have an interrupting rating at 240 VAC that matches the panelboard short circuit rating.
6. Main circuit breakers shall be individually mounted. Branch mounted circuit breakers are not acceptable unless specifically indicated on the panel schedules. Coordinate top or bottom mounting of main circuit breaker with incoming conduit location.
7. Where indicated on the Drawings, branch circuit breakers shall be provided with a padlockable hasp or handle padlock attachment for padlocking in the off position as required to meet the NEC requirement for disconnecting means and/or OSHA lock-out/tagout standard. Locking hardware shall remain in place even when the padlock is removed. Branch circuit breakers shall be provided with a similar lock-on device where indicated on the Drawings.

#### E. Directories

1. Approved directories with noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be furnished and installed in each panelboard. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Drawings, except as otherwise authorized by the Engineer.

## **2.04 POWER DISTRIBUTION PANELBOARDS (NOT USED)**

### **A. General**

1. Power distribution panelboards shall be of the configuration and rating as specified herein and as indicated on the Drawings. The panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal overload branch circuit breakers. Panelboards shall be UL 67 Listed and shall be constructed to NEMA PB1 standards. Panelboards shall be service entrance rated where indicated on the Drawings.
2. Power panelboards shall be equipped with a main breaker or main lugs complete with branch circuit breakers as indicated on the Drawings. The panelboards shall be suitable for flush or surface mounting.
3. Power distribution panelboards shall be fully rated and shall have a minimum short circuit rating of 65,000 amperes symmetrical unless otherwise indicated on the Drawings.
4. Power distribution panelboards shall be Eaton Pow-R-Line Series, the Square D Company equivalent, or the General Electric Company equivalent.

### **B. Enclosures**

1. Enclosures shall be UL 50 listed and have a NEMA rating as indicated on the Drawings. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet. Enclosures designated as NEMA 4X shall be constructed of 304 stainless steel. Enclosures with all other NEMA ratings shall be constructed of No. 12 U.S.S. code gauge galvanized steel, painted ANSI #61 light gray. The enclosure shall have wiring gutters on sides and shall be at least 5-3/4 inches deep.
2. The door shall be fastened to the enclosure with concealed hinges and shall be equipped with flush-type catches and locks. The Contractor shall equip cabinet doors exceeding 40 inches in height with vertical bolt three-point locking mechanism. All locks shall be keyed alike. The panelboard trim shall have a removable hinge assembly, in addition to the door hinge, that allows work inside the enclosure without the need to remove the trim.



3. The panelboard shall be provided with an information label. The information label shall include the panelboard designation, voltage, phase, wires, and bus rating.

#### C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1,000 amperes per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide full flexibility of circuit arrangement.
2. Solid neutral bus bars, where required, shall be provided. Neutral bus shall have the same ampacity as the main bus, unless otherwise indicated. Ratings shall be in accordance with applicable standards.
3. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.
4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.
5. All bus shall be tin plated copper and shall extend the entire useable length of the panelboard, including spaces. Panelboards Listed and Labeled as a four-wire panel shall not be used in place of a three-wire panel where a neutral conductor does not exist in the supply conductors to that panel.

#### D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type and UL 489 Listed. All circuit breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation.
2. Circuit breakers used for lighting circuit switching shall be approved for the purpose and shall be marked "SWD" where required by Article 440 by the NEC. Circuit breakers installed for air conditioning units shall be HACR type.
3. Circuit breaker voltage rating shall meet or exceed the panelboard voltage indicated on the Drawings. Trip elements of circuit breakers shall be 20A, unless otherwise indicated on the Drawings. Circuit breakers shall have an interrupting rating at 480 VAC that matches the panelboard short circuit rating.
4. Main circuit breakers shall be individually mounted. Branch mounted circuit breakers are not acceptable unless specifically indicated on the panel schedules. Coordinate top or bottom mounting of main circuit breaker with incoming conduit location.

5. Where indicated on the Drawings, branch circuit breakers shall be provided with a padlockable hasp or handle padlock attachment for padlocking in the off position as required to meet the NEC requirement for disconnecting means and/or OSHA lock-out/tagout standard. Locking hardware shall remain in place even when the padlock is removed. Branch circuit breakers shall be provided with a similar lock-on device where indicated on the Drawings.

E. Directories

1. Approved directories with noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be provided in each panel. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Drawings, except as otherwise authorized by the Engineer.

**2.05 COMBINATION POWER UNITS (NOT USED)**

**2.06 DC POWER SYSTEM PANELBOARD (NOT USED)**

**2.07 SURGE PROTECTIVE DEVICES**

- A. The panelboards shall be furnished with integrated Type II surge protective devices (SPD). SPDs shall be provided in the location and quantity as shown on the Drawings. SPD shall be installed within the panelboard enclosure in a location that allows the required quantity and rating of branch circuit breakers to be installed. Reducing the quantity of branch circuit breakers to less than that required by the panel schedules is not acceptable.
- B. The SPD shall be rated, designed, tested, listed, and labeled in accordance with UL-1449, latest edition.
- C. The SPD shall be factory installed by the panelboard manufacturer using a direct bus connection. There shall be no cable connection between the bus bar and the SPD device.
- D. The SPD shall have a fault current rating equal to or greater than that of the fault current rating of the panelboard. The SPD shall employ metal-oxide varistor (MOV) technology. If integral fusing is used, the fuses shall allow the maximum rated surge current to pass without fuse operation.
- E. The SPD shall have a maximum continuous operating voltage (MCOV) of at least 115% of the nominal voltage of the panelboard. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

<b>System Voltage</b>	<b>L-N</b>	<b>L-G</b>	<b>L-L</b>	<b>N-G</b>
208Y/120	700V	700V	1200V	700V
480Y/277	1200V	1200V	1800V	1200V
480 DELTA	N/A	1200V	2000V	N/A
240 DELTA	N/A	1200V	1200V	N/A
120/240	700V	700V	1200V	700V

- F. The Nominal Discharge Current (In) of the SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.
- G. The surge current rating for each SPD shall be as indicated on the Drawings. Surge current ratings are indicated in panel schedules. Surge current rating indicated is on a per phase basis.
- H. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

<b>System Configuration</b>	<b>Modes of Protection</b>	<b>Number of Modes</b>
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedance Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

- I. The SPD shall be furnished with an audible alarm and silence pushbutton, integral SPD status LEDs (one per phase), and a Form C dry contact for remote indication of alarm. A surge counter shall also be provided.
- J. The SPD equipment shall be SPD Series by Eaton, SurgeLogic by the Square D Company, Tranquell by the General Electric Company, or equal.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Panelboards shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer, and as required by NECA 407.
- B. Panelboards shall be set true and plumb in locations as shown on the Drawings. The top of panelboard enclosure shall not exceed six (6) feet above finished floor elevation.

- C. Enclosures shall not be fastened to concrete or masonry surfaces with wooden plugs. Appropriate cadmium plated or galvanized steel bolts shall be used with expansion shields or other metallic type concrete insert for mounting on concrete or solid masonry walls. Cadmium plated or galvanized steel toggle bolts shall be used for mounting on concrete block or other hollow masonry walls. Bolt diameter shall be as required considering the size and weight of the completed panelboard and enclosure to provide adequate structural support.
- D. The Contractor shall not use factory furnished knockouts with surface mounted back boxes. The Contractor shall punch or drill required openings during installation and shall equip flush mounted back boxes with manufacturer's standard pattern of knockouts.
- E. The Contractor shall install cabinets (and other enclosure products) in plumb with the building construction. Flush mounted enclosures shall be installed so that the trim will rest against the surrounding surface material and around the entire perimeter of the enclosure.
- F. Bus loads in all panelboards shall be balanced between phases to within a tolerance of one (1) KVA. Convenience receptacles shall be distributed evenly among all phase buses as much as practical.
- G. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

### **3.02 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. Field Tests
    - a. Prior to termination of any conductors to the circuit breakers, all bus work and circuit breakers shall be tested from phase to phase and phase to ground with a 1000 VDC megaohmmeter for 1 minute in accordance with NECA 407. Resistance values shall be recorded and shall not be less than 100 megohms.
    - b. Prior to terminating any wires to the circuit breakers, the resistance of the connection between the bus work and each circuit breaker shall be tested through the use of a low-resistance ohmmeter. Record the resistance values for each circuit breaker.

**END OF SECTION**

**SECTION 26 24 19**  
**LOW VOLTAGE MOTOR CONTROL CENTERS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, test, and place in satisfactory operation, the motor control centers as specified herein and indicated on the Drawings.
- B. The Contractor shall obtain the motor control centers from one manufacturer who shall also manufacture the enclosure and major equipment components, which includes, but is not limited to, combination starters, reduced voltage solid state starters, circuit breakers, power monitoring equipment, and other components of the equipment assembly. Subcontracting of wiring is not acceptable.
- C. The motor control center shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.
- D. Reference Section 26 05 00 – Basic Electrical Requirements; Section 26 05 53 – Identification for Electrical Systems; Section 26 09 16 – Electric Controls and Relays; Section 26 22 00 – Low Voltage Transformer; and Section 26 24 16 - Panelboards.

**1.02 CODES AND STANDARDS**

- A. The assemblies shall meet or exceed the requirements within the following standards for motor control centers:
  - 1. NEMA ICS-18
  - 2. UL845
- B. The motor control center shall be designed, manufactured, and tested in facilities registered to the following quality standards:
  - 1. ISO 9001

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings.

2. Spare Parts List.
  3. Proposed Testing Methods and Reports of Certified Shop and Field Tests.
  4. Manufacturers Startup Certification
  5. Operation and Maintenance Manuals.
- B. Each submittal shall be identified by the applicable specification section.

#### **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings for each motor control center shall include but not be limited to:
1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.
  2. Product data sheets.
  3. Example equipment nameplate data sheet.
  4. Approximate total shipping weight of each shipping split.
  5. Plan, front, and side view drawings, including overall dimensions of each motor control center. Identify shipping splits and show conduit stub-up area locations on the Drawings.
  6. Internal schematic and point-to-point wiring diagrams of each motor control unit including reduced voltage solid state starters integrated into the motor control

center. Standard wiring diagrams that are not custom created by the manufacturer for the motor control centers for this project are not acceptable. One wiring diagram which is typical for an equipment group (e.g. influent pump, exhaust fan) is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

7. Complete single-line diagrams for each motor control center showing circuit breakers, motor circuit protectors, motor controllers, instrument transformers, meters, relays, timers, control devices, dry-type transformers, panelboards, and other equipment comprising the complete assembly. Indicate electrical ratings of equipment and devices on these single-line diagrams. Ratings include starter size and type, motor circuit protector continuous current rating, circuit breaker frame size and trip rating, transformer ratings panelboard ratings, motor horsepower and full load current, and similar information.
  8. Bill of material list for each motor control center and each motor control unit.
  9. Nameplate schedule for each motor control center.
  10. Manufacturer's installation instructions.
  11. Key interlock scheme drawing and sequence of operations.
  12. Manufacturer's Warranty Statement
  13. Table listing all motor loads connected to the motor control center. Table shall include the full load amps of the APPROVED motors. Final approval of MCC shop drawings cannot be given until all motor loads for MCC have been reviewed, approved, and shown in this table.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.
- E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each motor control center unit of each motor control center. These final drawings shall be included in the O&M manuals.

#### **1.05 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

## **1.06 SPARE PARTS**

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor. In addition to the manufacturer recommended spare parts, the Contractor shall furnish the following spare parts for each motor control center:
1. One (1) set of fuses of each size provided
  2. One (1) starter coil and complete set of contacts for each size and type of starter provided
  3. One (1) relay of each type and size provided
  4. One (1) control power transformer of each size provided
  5. Two (2) lamps and lenses for indicating lights for each color provided
  6. One (1) indicating lamp socket for each type provided
  7. One (1) pilot device (e.g. pushbutton, selector switch, etc.) complete with contact blocks and legend plates for each type, size, and rating provided
  8. One (1) motor circuit protector for each type, size, and rating provided
  9. One (1) circuit breaker for each type, size, and rating provided (except main circuit breakers)
- B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.
- D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Term such as "1 lot of packing material" are not acceptable.
- E. Parts shall be completely identified with a numerical system to facilitate parts control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

## **1.07 IDENTIFICATION**

- A. Each motor control center shall be identified with the identification number indicated on the Drawings (e.g., MCC, etc.). A nameplate shall be securely affixed in a conspicuous



place on each motor control center. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. It is the intent of these specifications that all components of the motor control center be provided by one manufacturer who shall have the sole responsibility of matching all components and providing equipment which functions together as a system. The manufacturer of the motor control center shall also be the manufacturer of the motor controllers. The use of third-party supply and assembly of these components is not acceptable.
- C. Motor control centers shall be Freedom 2100 as manufactured by Eaton using NEMA rated Freedom Series contactors and starters, Model 6 as manufactured by the Square D Company, Centerline 2100 as manufactured by Allen-Bradley, or the General Electric Company Evolution Series E9000. No substitutions allowed.

### **2.02 MOTOR CONTROL CENTER**

- A. General
  - 1. The motor control centers shall be 600 VAC class suitable for operation on a three-phase, 60 Hz system. The motor control centers and their components shall conform to the requirements of applicable standards of NEMA Part ICS 2-322 and Underwriters' Laboratories, Inc. UL-845. Wiring shall be NEMA Class II, Type B. Each vertical section shall be a NEMA 1A (gasketed) industrial use enclosure unless otherwise specified or indicated on the Drawings.
  - 2. The enclosures shall be cleaned, primed, and finish coated in accordance with the manufacturer's standard process. The pre-treatment process shall be a zinc chromate primer followed by a "One Coat" paint process that is monitored to meet the manufacturer's specifications for paint color, texture, thickness, and durability. Enclosure interior and exterior finish color shall be ANSI 49 (medium light gray). The color of the back panel/bucket located within the MCC enclosure shall be white.
  - 3. The motor control centers shall be capable of withstanding the fault current available at its line terminals. Minimum bus bracing, withstand, and interrupting ratings are specified herein.

4. Unless otherwise specified or indicated on the Drawings, each vertical section shall be approximately 20 inches wide, and 90 inches high, 20 inches deep, and shall not contain more than six NEMA Size 1 starters. Motor control centers shown "back-to-back" on the Contract Drawings shall be complete motor control assemblies placed back-to-back in the location shown. Motor control center sections with common horizontal and/or vertical bus systems are unacceptable.
5. Continuous horizontal wiring troughs shall be provided at both the top and bottom of each section. These troughs shall line up to form a continuous wireway for the full length of the motor control center. Each section shall be provided with a large, continuous, full height vertical wiring trough in the right side of each section. Each vertical wiring trough shall be furnished complete with tie bars for conductor support.
6. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of unit; No. 12 AWG (minimum). Wiring shall be type MTW rated for 105°C. Wire color coding shall be red for control and black for power. Wire numbers shall not be repeated in a motor control center.
7. Starter units shall contain the number of auxiliary contacts, unit-mounted pilot devices and indicating lights, control relays, elapsed time meters, and other devices as shown on the Drawings and required for the applications. A minimum of two (2) normally open (NO) and two (2) normally closed (NC) spare contacts shall be provided for each magnetic starter. These spare contacts shall be shown on the submittal wiring diagrams.
8. The motor control centers shall be furnished with warning signs to notify maintenance personnel of multiple sources of power within the motor control units.

B. Power

1. The motor control centers shall be supplied from a 480V, 3-phase, 3 or 4 wire as indicated on the Drawings, 60 Hz power source. The incoming power feeders shall be sized as shown on the Drawings. All terminals for incoming and outgoing power cables shall be provided with compression lugs.

C. Bus

1. Power shall be distributed by means of a continuous, tin plated copper horizontal bus, rated as shown on the Drawings. The bus shall be braced for 65,000A rms symmetrical at 480V unless otherwise indicated on the Drawings. The horizontal bus shall be effectively isolated from all wiring troughs and other working areas. Vertical bus extensions shall be tin plated copper, isolated by rigid, glass-polyester moldings so as to be a separate self-supported assembly. Silver plated vertical bus may be provided if specifically accepted by the Engineer. Full height vertical

bus shall be installed in all sections including those containing spare units and "prepared" spaces. No extra safety jacks or similar devices shall be required to obtain an essentially dead-front condition. Access shall be provided for inspection and maintenance from the front. Minimum horizontal bus rating shall be 600A. Minimum vertical bus rating shall be 300A.

#### D. Incoming Line Units

1. Each incoming line unit shall contain buswork and fittings as required with cable lugs for cables of sizes and quantities shown on the Drawings. Cable lugs shall be suitable for their respective conductors.

#### E. The Unit Compartments

1. Each unit compartment shall be provided with an individual front door hinged to the vertical structure. Each plug-in unit shall be supported and guided by a removable unit support pan, so that the unit rearrangement is easily accomplished. The rearrangement of the unit support pan from one location to the other shall be accomplished without use of tools. After insertion, each plug-in unit shall be held in place by at least one multi-turn latch, located at the front of the unit. The latch shall be located for front accessibility and installation convenience. An additional mechanical interlock shall be provided to prevent withdrawal of the unit from the stationary structure with the operating mechanism in the ON position.
2. The unit plug in power stabs shall be electromagnetically tin-plated copper to yield a low resistance connection and designed to tighten during heavy current surges and short circuits. The stab shall be backed by spring steel clips to provide and maintain a high pressure, two-point connection to the vertical bus. They shall be free floating and self-loading plug-in. Wiring from the unit disconnecting means to the plug-in stab shall be exposed at the rear of the unit. The power cable terminations at the plug-in stab shall be mounted in a two-piece, glass polyester support assembly. This support assembly shall provide a separate isolated pathway for each phase, minimizing the probability of a unit fault condition reaching the power bus system.
3. NEMA Size 1 through Size 5 non-reversing starters shall be plug-in units. Size 1, 2, and 3 shall utilize stab assembly rated 100A. Stab assemblies for Size 4 and Size 5 starters shall be rated for the starters maximum output current rating.
4. An industrial, heavy-duty flange handle mechanism shall be supplied for the control of each disconnecting means. This mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position. The operator handles shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator. It shall be possible to lock the handle

in the "OFF" position with up to three (3) 3/8-inch diameter shackle padlocks and in the "ON" position with one (1) 3/8 inch diameter shackle padlock.

5. The operator handle of all units shall be interlocked with the door units so that the disconnect means cannot be switched unless the door unit is closed. A means shall be provided for purposely defeating the interlock during maintenance or testing. This interlock shall also prevent opening the unit door unless the disconnecting means is in the off position. An externally operated def eater requiring the use of a screwdriver shall provide access to the unit without interrupting service.
6. The overload relays shall be resettable from the outside of the enclosure by means of an insulated bar or button.

#### F. Ground Bus

1. The horizontal ground bus shall be tin plated copper and located in the bottom horizontal wireway. The minimum size of the horizontal ground bus shall be ¼-inch x 1 inch (6.35mm x 25.4mm) or 33% of the phase bus ampacity, whichever is greater.
2. Compression lugs shall be mounted on the ground bus in each section, in the size and quantity as required for the termination of system and equipment grounding conductors.
3. The vertical ground bus shall be tin plated copper and solidly connected to the horizontal ground bus. This ground bus, in combination with the unit ground bus stab, establishes unit grounding before the plug-in power stabs engage the power bus, and conversely, as the unit is withdrawn, grounding is maintained until after the plug-in power stabs are disengaged.
4. The vertical load ground bus shall be tin plated copper and solidly connected to the horizontal ground bus. The vertical load ground bus assembly, comprised of the vertical load ground bus and the unit load ground bus connector, shall provide a termination point for the load equipment grounding conductor at the unit. This fixed connection shall not have to be removed when the unit is withdrawn from the motor control center.

#### G. Isolation and Insulation

1. Horizontal bus access covers and vertical bus covers shall isolate the energized buses to guard against the hazard of accidental contact. These covers shall be molded of a glass polyester material.
2. The horizontal bus shall be isolated from the top horizontal wireway by a grounded steel barrier. This barrier shall be removable to allow access to the bus and connections for maintenance.

3. The vertical bus cover shall provide unit plug-in openings which shall permit unit plug-in stab assemblies to pass through and engage the vertical bus. The unit plug-in openings shall be sized to minimize the probability of inadvertent contact with the vertical bus.
4. Isolation of unused stab openings shall be accomplished by use of a manual shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the motor control center.
5. All units shall be isolated from one another, above and below, by unit support pans or steel barriers, which can remain in place when the units are withdrawn.
6. Incoming line compartments shall be isolated from horizontal and vertical wireways by steel barriers.
7. A molded unit isolating barrier shall be provided to isolate the unit from the vertical wireway.

#### H. Combination Motor Control Units

1. Motor branch circuits shall be protected by a motor circuit protector (MCP).
2. The motor circuit protector shall be operated by a toggle type handle and shall have a quick make, quick break overcenter switching mechanism that is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits and abnormal currents. Tripping shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. All latch surfaces shall be ground and polished. All poles shall be so constructed that they open, close, and trip simultaneously.
3. Each pole of these motor circuit protectors shall provide instantaneous short circuit protection by means of an adjustable magnetic only element.
4. The motor circuit protectors in combination with a contactor and overload relay shall have an interrupting rating that matches the motor control center short circuit rating at 480V.
5. Motor circuit protector's ratings, modifications, etc., shall be as specified herein and as indicated on the Drawings.
6. Motor circuit protectors shall be completely enclosed molded case devices with a current sensing coil in each of the 3 poles and have a magnetic trip adjustment located on the front. The motor circuit protector shall be manually operable. The protector shall be designed to meet the NEC requirement concerning motor full load and locked-rotor current. Ampere ratings shall be clearly visible. Contacts

shall be of non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes, consisting of metal grids mounted in an insulating support.

#### I. Motor Starters

1. Motor starters shall conform to NEMA Standard IC1 and shall be for across-the-line starting, unless otherwise indicated. IEC rated equipment is not acceptable and shall be used as a basis for rejection of the equipment. The size of the starter shall be as required for the particular load. Minimum starter size shall be NEMA Size 1. Size 1 and 2 starters shall be completely drawout type, so that units may be withdrawn without disconnecting any wiring. Size 3 and 4 full-voltage, non-reversing starters shall be drawout type after disconnecting power leads only. Starters over three-space units high may be bolt-on type. A positive guidance system shall be provided to assure proper alignment of wedge-shaped power stabs in deadfront openings in vertical power bus.
2. A suitable control disconnect device(s) to comply with the requirements of the NEC shall be provided.
3. Magnetic starters and contactors shall be electromagnetic vertical or horizontal lift design with double break cadmium oxide silver contacts. Design shall meet or exceed the requirements of UL and NEMA Standards. Coils shall be hot molded construction to protect the coils from mechanical and environmental damage.
4. Each starter shall be able to accommodate a minimum of three (3) auxiliary contacts in addition to the hold-in contact.
5. Each starter shall be supplied with a 3-pole, manual reset overload relay. The relays shall be solid state type, with at least one isolated normally open and one isolated normally closed auxiliary contact that operates when a trip condition has occurred. Relays shall be self-powered, have a visible trip indicator, have a trip test function, and have selectable Class 10 or 20 operation. Overload relays shall be set for Class 10 operation unless otherwise directed by the Engineer. Overload relay shall have phase loss protection built in to trip the unit and protect the motor against single phasing. The Contractor shall provide the overload relay model with the correct current range for each application. Overload relay shall have adjustable current range dial. Eutectic alloy or bi-metallic type overload relays are not acceptable.
6. Each motor starter coil shall be equipped with a surge-suppression device for protection of the solid-state equipment (e.g. programmable logic controller) wired as part of the control circuit.
7. The Contractor and motor control center manufacturer is advised to review the Contract Documents for additional requirements for space heaters, power factor correction capacitors, and similar equipment which may not be specified in this Division or shown on the Drawings. Control power transformers shall be fused on

both the primary and secondary sides. The minimum control power transformer VA requirements are shown below. Control power transformers shall be sized as required for the connected loads, plus 25% spare capacity.

- a. Size 1-75 VA
  - b. Size 2-75 VA
  - c. Size 3-200 VA
  - d. Size 4-300 VA
  - e. Size 5-500 VA
8. Reduced voltage solid state starters shall be provided for the motor loads as specified herein and as indicated on the Drawings.

#### J. Circuit Breakers

1. Where specified herein, indicated on the Drawings, or required, the main circuit breaker shall be rated for service entrance and bear a service entrance label.
2. Unless otherwise indicated, circuit breakers shall be manually operable and shall provide thermal-magnetic, inverse-time-limit overload, and instantaneous short-circuit protection.
3. Circuit breakers shall be molded case type, rated 480 VAC, 2 or 3 pole and have 100 ampere or larger frames. The interrupting rating shall match that of the motor control center short circuit rating at 480V.
4. Overload protection shall be provided on all poles with trip settings as indicated on the Drawings. Breakers of 225-ampere frames and larger shall have interchangeable trip units and adjustable magnetic trip elements.
5. Horizontally mounted operator handles for feeder circuit breaker units up to 225A are permissible if accepted in writing by the Engineer.

#### K. Terminal Blocks

1. Terminal blocks associated with removable units within the motor control center shall be provided as follows:
  - a. Terminal blocks shall be mounted within the unit insert and in the front for ease of accessibility.
  - b. Pull-apart style terminal block assemblies shall be provided. Terminal block assembly shall consist of a male and female component held together with captive screws. The terminal block assembly shall be designed to withstand

the effects of vibration, yet able to be pulled apart without difficulty. The terminals of the assembly shall be recessed to isolate them from accidental contact. Terminal markings shall be provided for the purpose of identifying terminations. Terminal strips shall be suitable for use as a disconnecting means of foreign interlock voltages.

- c. For starters Size 2 and smaller, terminate all starter wiring (power and control) and external field wiring on terminal blocks provided in each unit.
  - d. For starters Size 3 and larger, terminate control wiring and external field control wiring on terminal blocks provided in each unit.
2. Terminal blocks associated with non-removable units within the motor control center shall be provided in accordance with Section 26 09 16 – Electric Controls and Relays.
  3. Provide a minimum of four (4) spare terminals in each terminal block assembly.

#### L. Control Devices

1. Furnish and install control devices as required and/or shown on the Drawings. The following control devices shall be provided as specified in Section 26 09 16 – Electric Controls and Relays:
  - a. Pilot devices (switches, indicating lights, etc.)
  - b. Relays and timers

M. Transformers: As specified in Section 26 22 00, Low Voltage Transformers.

N. Panelboards: As specified in Section 26 24 16, Panelboards.

#### O. Nameplates

1. Provide engraved plastic nameplates to identify the motor control center, each unit compartment, door mounted devices, and internal components.
2. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems. Equipment names and numbers as indicated on the single line diagrams shall be used as the basis to engrave the nameplates.
3. Provide a master nameplate giving motor control center designation, voltage rating, ampere rating, short circuit rating, manufacturer's name, general order number and item number.
4. Control components mounted as part of the assembly, such as fuse blocks, control relays, pushbuttons, switches, and similar devices, shall be suitably marked for



identification corresponding to appropriate designations on the manufacturer's wiring diagrams.

**P. Future Space Requirements**

1. Provide spaces for future combination starter and other units in the motor control centers. Furnish spaces with hardware to accommodate future plug-in control unit without modification of vertical sections. Provide the number of spaces required for future units as indicated on the Drawings, minimum.
2. Provide additional vertical sections to ensure total number of spaces as indicated on the Drawings. The number of vertical sections is contingent upon specific manufacturer's final proposed and Engineer-accepted configuration of motor control center units.

**Q. Metering**

1. Each motor control center assembly shall be furnished and installed with an Square D ION7400 Series power quality meter or equivalent Allen-Bradley and Eaton product as indicated on the Drawings. Provide with Ethernet communication provisions.

**2.03 SURGE PROTECTIVE DEVICES**

- A. The motor control center shall be furnished with integrated Type II surge protective devices (SPD). SPDs shall be provided in the location and quantity as shown on the Drawings.
- B. The SPD shall be rated, designed, tested, listed, and labeled in accordance with UL-1449, latest edition.
- C. The SPD shall be factory installed by the motor control center manufacturer using a direct bus connection. There shall be no cable connection between the bus bar and the SPD device.
- D. The SPD shall have a fault current rating equal to or greater than that of the fault current rating of the motor control center. The SPD shall employ metal-oxide varistor (MOV) technology. If integral fusing is used, the fuses shall allow the maximum rated surge current to pass without fuse operation.
- E. The SPD shall have a maximum continuous operating voltage (MCOV) of at least 115% of the nominal voltage of the motor control center. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

<b>System Voltage</b>	<b>L-N</b>	<b>L-G</b>	<b>L-L</b>	<b>N-G</b>
208Y/120	700V	700V	1200V	700V

480Y/277	1200V	1200V	1800V	1200V
480 DELTA	N/A	1200V	2000V	N/A
240 DELTA	N/A	1200V	1200V	N/A
120/240	700V	700V	1200V	700V

- F. The Nominal Discharge Current (In) of the SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.
- G. The surge current rating for each SPD shall be as indicated on the Drawings. Surge current ratings are indicated on single line diagrams. Surge current rating indicated is on a per phase basis.
- H. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

System Configuration	Modes of Protection	Number of Modes
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedance Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

- I. The SPD shall be furnished with an audible alarm and silence pushbutton, integral SPD status LEDs (one per phase), and a Form C dry contact for remote indication of alarm. A surge counter shall also be provided.
- J. The SPD equipment shall be SPD Series by Eaton, SurgeLogic by the Square D Company, Tranquell by the General Electric Company, or equal.

## 2.04 REDUCED VOLTAGE SOLID STATE STARTER

- A. Reduced-voltage starters shall be solid-state, combination type complete with motor circuit protector (MCP). RVSS shall be rated 480 VAC, 3-pole, sized for continuous operation at 115% of its continuous ampere rating unless otherwise indicated. RVSS shall be rated 30,000 AIC minimum unless indicated otherwise.
- B. The RVSS shall be provided with a human machine interface (HMI) that includes an LCD display and a keypad for scrolling through menus. The HMI shall be door mounted.
- C. The RVSS shall be UL Listed. The solid-state reduced-voltage starter shall be an integrated unit with power SCRs, logic board, an integral paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing. The starter shall meet all applicable requirements of this Section and other sections in this Division.

- D. The RVSS shall be suitable for the following environmental conditions: Operating Temperature: 0-50 degrees C; Humidity: 0-95 percent non-condensing; Altitude: up to 3,300 feet.
- E. The SCR-based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 1500 volts PIV. Units using triacs or SCR/diode combinations are not acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt effects.
- F. The paralleling run bypass contactor shall energize when the motor reaches full speed and close/open under one (1) times motor current.
- G. The starter shall be provided with electronic overload protection as standard and shall be based on an inverse time-current algorithm. Overload protection shall be capable of being disabled during ramp start for long acceleration loads via a DIP switch setting on the device keypad. Overload protection shall be adjusted via the device keypad and shall have a motor full load ampere adjustment from 30 to 100% of the maximum continuous ampere rating of the starter. The starter shall have selectable overload class setting of 5, 10, 20 or 30 via a DIP switch setting on the device keypad. The starter shall be capable of either an electronic or mechanical reset after a fault. Units using bimetal or eutectic alloy overload relays are not acceptable.
- H. The starter shall provide protection against the following conditions:
  - 1. Improper line-side phase rotation. The starter shall stop the motor load if a line-side phase rotation other than A-B-C exists.
  - 2. Phase loss or unbalanced conditions. The starter shall stop the motor load if a 50% current differential between any two phases is encountered.
  - 3. Motor stall conditions.
  - 4. Motor jam conditions.
- I. The following control function adjustments on the device keypad shall be provided:
  - 1. Selectable Torque Ramp Start (10% to 90%) or Current Limit Start (100% to 450%)
  - 2. Adjustable Kick Start Time, 0-2 seconds
  - 3. Adjustable Kick Start torque, 0-90%
  - 4. Adjustable Ramp Start Time; 0.5-180 seconds
  - 5. Adjustable Initial Starting Ramp Torque; 0-100%
  - 6. Adjustable Smooth Stop Ramp Time; 0-60 seconds.

- J. The reduced voltage solid state starter shall be the SMC-Flex with integral bypass as manufactured by Allen-Bradley, Eaton equivalent, the General Electric Company equivalent, or the Square D Company equivalent.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. The motor control centers shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.
- B. Install motor control centers to allow complete unit door swing required for unit removal. This is specifically required where a vertical section of motor control center is set next to a wall to the left of the motor control center section.
- C. Where motor control center structures are located away from walls to allow bottom conduit entry, the Contractor shall furnish and install sheet metal coverings for openings along the sides and top of the motor control center line-up. The purpose of the coverings is to minimize dust, dirt, and undesirable materials from collecting behind the equipment. The sheet metal coverings shall be of the same material, gauge, and finish as the motor control center.
- D. Motor control centers shall be furnished with anchor bolts as required for aligning and mounting. Floor channels with end covers shall be of type recommended by the manufacturer and shall be furnished for installation in a concrete pad.
- E. All field wiring that is terminated directly to a unit within the motor control center shall be neatly routed in a manner that does not hinder the ability to service, adjust, or replace components within that unit. Field wiring shall be properly anchored to the motor control center and individual unit structures.
- F. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

### **3.02 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. Witnessed Shop Tests
    - a. None required.
  - 2. Certified Shop Tests and Reports

- a. Submit description of proposed testing methods, procedures, and apparatus. Submit notarized and certified copies of all test reports.
  - b. As a minimum, the entire motor control center shall go through a quality inspection before shipment. This inspection shall include, but is not limited to, the following:
    - 1) Physical inspection of the structure and the electrical conductors including bussing, general wiring, and units.
    - 2) General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.
    - 3) AC dielectric tests of the power circuits and control circuits.
    - 4) Markings/labels, including instructional type, Underwriters Laboratory (UL), and inspector's stamps.
3. The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the motor control center.

#### B. Field Tests

1. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

### **3.03 FIELD ADJUSTMENTS**

- A. All adjustable settings of circuit breakers shall be set in the field by a qualified representative of the manufacturer, or an outside testing company retained by the Contractor, in accordance with the settings designated in the coordination study. See Section 26 05 00 – Basic Electrical Requirements.
- B. The settings of the motor circuit protectors and overload relays shall be set based on the coordination study and the motor nameplate data of the motors installed.

### **3.04 SERVICES OF MANUFACTURER'S REPRESENTATIVE**

- A. The Contractor shall provide the services of a qualified, factory-trained manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

- B. The manufacturer's technical representative shall perform startup and functional testing of the equipment as specified herein.
- C. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for [two (2) sessions of two (2) hours each]. Training shall be at times coordinated with the Owner. Training shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.
- D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:
  - 1. One (1) trip of one (1) working day during the installation and startup of the equipment.
  - 2. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify any issues to be corrected under warranty.
  - 3. One (1) trip of one (1) working day to perform training as specified herein.
- E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

**END OF SECTION**

**SECTION 26 27 26**  
**WIRING DEVICES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install all switches, occupancy sensors, and receptacles as shown on the Drawings.
- B. All switches and receptacles shall be furnished and installed in outlet boxes. Reference Section 26 05 33.16 – Boxes for Electrical Systems, for outlet box requirements.
- C. Reference Section 26 05 00 – Basic Electrical Requirements, and Section 26 05 19 – Low-Voltage Conductors and Cables.

**1.02 CODES AND STANDARDS**

- A. Wiring devices shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. UL 20 – General Use Snap Switches
  - 2. UL 498 – Standard for Attachment Plugs and Receptacles
  - 3. UL 943 – Ground Fault Circuit Interrupters
  - 4. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

**1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include, but not be limited to:

1. Product data sheets.

### **1.05 SPARE PARTS**

- A. The Contractor shall furnish 10% (minimum of 1) spare of each receptacle, switch, and plug furnished and installed for this project.
- B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

### **1.06 IDENTIFICATION**

- A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The Contractor shall use the products of a single manufacturer for each type of wiring device.
- C. The Contractor shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:
  1. Where the selected plate manufacturer does not manufacture a suitable finish plate.
  2. For heavy-duty receptacles rated at more than 30A.
  3. Where non-standard plates are required, specified, or shown.
- D. The Contractor shall furnish and install all wiring devices and device plates.



- E. In non-hazardous areas, provide specification grade devices manufactured by Appleton, Crouse-Hinds, Leviton, Hubbell, Pass & Seymour, or Engineer approved equal.
- F. In hazardous areas, provide devices manufactured by Appleton, Cooper Crouse-Hinds, Hubbell-Killark, or Engineer approved equal.

## **2.02 WIRING DEVICES**

- A. Wall switches for non-hazardous areas shall be rated for the current required to suit the application, but not less than 20A. Double pole, three-way, and four-way switches shall be provided where indicated on the Drawings, and as required. Switches shall be rated for 120-277VAC and shall be UL 20 Listed.
- B. Convenience receptacles for non-hazardous areas shall be rated for 20A at 125VAC and shall be UL 498 Listed. Receptacles shall be weather resistant where installed in wet or damp locations.
- C. Special purpose receptacles (welders, lab equipment, etc.) shall be provided with the proper NEMA configuration and ampacity as indicated on the Drawings. The coordinating plug for each special purpose receptacle shall be provided with the equipment which it is serving.
- D. Ground fault circuit interrupter receptacles shall be rated for 20A at 125VAC and shall be UL 943 Listed. Receptacles shall be weather resistant where installed in wet or damp locations.
- E. Wall switches for hazardous areas shall be the factory sealed type, UL 1203 Listed for use in the hazardous area. Wall switches shall be rated for 120-277VAC, and shall be rated for the current required to suit the application, but not less than 20A
- F. Receptacles for hazardous areas shall be rated 20A at 120-240VAC. Receptacles shall be UL 1203 listed for use in the hazardous area, utilizing delayed-action construction.
- G. All wiring devices shall be approved for use with stranded conductors, if stranded conductors are to be used with the device. Reference Section 26 05 19 – Low-Voltage Conductors and Cable for conductor requirements

## **2.03 DEVICE PLATES**

- A. Device plates for indoor flush-mounted receptacles and switches shall be made of Type 304 stainless steel, not less than 0.032 of an inch thick, with beveled edges and milled on the rear so as to lie flat against the wall. Devices plates shall be provided with a gasket.
- B. Device plates for outdoor installations, indoor wet process areas, and chemical storage/transfer areas shall be Appleton Type FSK, Crouse-Hinds #DS185, or equal for wall switches. Device plates for receptacles shall be “in-use” style. “In-use”

weatherproof covers shall be rugged, minimum 3 ¼" depth, die-cast aluminum as manufactured by Thomas & Betts "Red Dot," Intermatic International, Inc., or equal.

- C. Device plates for indoor dry process and non-process areas with surface mounted boxes shall be Crouse-Hinds DS32, or equal for switches, and Crouse-Hinds DS23 or equal for receptacles.

## **2.04 PLUGS**

- A. The Contractor shall furnish suitable plugs with equipment furnished under the respective specification Section. Plugs shall be black rubber or plastic. For waterproof receptacles, the plugs shall be similar in construction to the receptacles and shall be encased in corrosion resistant yellow housing provided with clamping nuts and stuffing gland cable outlets.

## **2.05 PROCESS INSTRUMENTS**

- A. The Contractor shall furnish and install a local disconnect switch at each process instrument (e.g., level transmitter, flow transmitter, analytical instrument etc.,) to disconnect the 120VAC power supply to the instrument. The device shall be a NSSC series manual motor starting switch without overload protection as manufactured by Crouse-Hinds, Appleton equivalent, or equal. For hazardous locations, the device shall be UL 1203 Listed.

## **2.06 OCCUPANCY SENSORS (NOT USED)**

# **PART 3 – EXECUTION**

## **3.01 INSTALLATION**

- A. Where more than one (1) switch occurs at one (1) location, gang plates shall be used.
- B. All device plates shall be set true and plumb and shall fit tightly against the finished wall surfaces and outlet boxes.
- C. Wiring device box (outlet box) mounting heights shall be as specified in Section 26 05 33.16 – Boxes for Electrical Systems.
- D. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the Contractor shall bring it to the attention of the Engineer for a decision.
- E. Receptacles installed in toilet, locker, and bathrooms, and within 6 feet of a sink, shall be of ground fault interrupter type. Ground fault circuit interrupter receptacles shall also be furnished and installed in additional locations where indicated on the Drawings, and as required by the NEC.

- F. All receptacles shall have a self-adhesive label installed on the top at the respective device plate that indicates which panel and which circuit number the receptacle is supplied from. Labels shall have a white background and black lettering in 14-point font.

### **3.02 CIRCUITING**

- A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience receptacles are permitted per 20A, 120V circuit, unless otherwise indicated on the Drawings.

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**SECTION 26 28 16.16**  
**ENCLOSED SWITCHES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install separately mounted, individual disconnect switches as specified herein and indicated on the Drawings.
- B. Disconnect switches for process instruments are not included in the scope of this Section and shall be as specified in Section 26 27 26 – Wiring Devices.

**1.02 CODES AND STANDARDS**

- A. Disconnect switches shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. UL 98 – Enclosed and Dead-Front Switches
  - 2. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.
  - 3. NEMA 250 – Enclosures for Electrical Equipment
  - 4. NEMA KS 1 – Heavy Duty Enclosed and Dead-Front Switches

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings
  - 2. Spare Parts List
  - 3. Each submittal shall be identified by the applicable specification section.

**1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

- B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
  - 1. Product data sheets.
  - 2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of disconnect switch.
  - 3. Assembled weight of each unit.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

#### **1.05 SPARE PARTS**

- A. The equipment shall be furnished with all spare parts as recommended by the equipment manufacturer.
- B. One (1) complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the Owner at the time of final inspection.
- C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

#### **1.06 IDENTIFICATION**

- A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Section 26 05 29 – Identification for Electrical Systems.

## PART 2 – PRODUCTS

### 2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. Switches shall be manufactured by the Square D Company, Eaton, or the General Electric Company.

### 2.02 DISCONNECT SWITCHES

- A. Disconnect switches shall be heavy-duty type and/or as specified in these Specifications. Switches shall be furnished and installed as shown on the Drawings and as required by the NEC. Handles shall be lockable.
- B. Disconnect switches for non-hazardous areas shall be UL 98 Listed. Disconnect switches for hazardous areas shall be UL 1203 Listed.
- C. Switches shall meet NEMA Standard KS 1 type HD requirements, be, single-throw, be externally operated, and be fused or non-fused as indicated on the Drawings. Switches shall have the number of the poles, voltage, and ampere ratings as shown on the Drawings.
- D. In non-hazardous locations, disconnect switches shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

- E. In hazardous locations, disconnect switches shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

<b>Area Classification</b>	<b>Enclosure Type and Material</b>
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 7, Die Cast Aluminum
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 9, Die Cast Aluminum

- F. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.
- G. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.
- H. Disconnect switches shall be furnished with a factory installed internal barrier kit that helps prevent accidental contact with live parts and provides "finger-safe" protection when the door of the enclosed switch is open.
- I. Disconnect switches shall be furnished with a manufacturer-supplied ground lug kit for termination of equipment grounding conductors. Where a grounded (neutral) conductor is shown on the Drawings in the conduits connected to the disconnect switch, a manufacturer-supplied neutral bar shall be furnished for termination of the grounded conductors. Third party ground lug and neutral lug kits not supplied by the disconnect switch manufacturer are not acceptable.
- J. Fused disconnect switches shall be furnished for motor operated valve and gate actuators where shown on the Drawings. The Contractor shall coordinate the supply of these fused switches with the specific requirements of the actuator. Fuses with fast fault clearing times may be required for modulating valve actuators.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. All disconnect switches shall be mounted five (5) feet above the floor or finished grade, at the equipment height where appropriate, or where shown otherwise.
- B. Disconnect switches shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.



### **3.02 TESTING**

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Field Tests

- a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

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**SECTION 26 32 13**  
**ENGINE GENERATORS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install an NEC Article 701 Legally Required Standby power engine generator set complete with all accessories and appurtenances as required and as specified herein.
- B. It is the intent under this Contract to require an installation complete in every detail whether or not indicated on the Drawings or specified. Consequently, the Contractor is responsible for all details, devices, accessories and special construction necessary to properly install, adjust, test, and place in successful and continuous operation the engine-generator set.
- C. Use materials which are new, unused, and as specified. If not specifically indicated, use the best and most suitable materials of their kinds for the purpose intended, and for the design and expected conditions of service, subject to the approval of the Engineer.
- D. Provide workmanship that is first class in every respect. Employ workers thoroughly experienced in such work. A neat and workmanlike appearance in the finished work shall be required.
- E. All materials used must bear the inspection labels of the Underwriter's Laboratories, if the material is of a class inspected by the Laboratory.
- F. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.
- G. The engine generator sets shall fully comply with all current Environmental Protection Agency (EPA) emission regulations including, but not limited to, the New Source Performance Standards (NSPS) for stationary and non-road generator sets. The engine generator set(s) must meet the EPA new source performance requirements required at the time the engine generator set(s) submittal is approved by the engineer. Engines manufactured previous to the submittal approval date that do not meet the current regulated emissions levels are not acceptable.
- H. Reference Section 26 05 00 – Basic Electrical Requirements, Section 26 05 19 – Low-Voltage Conductors and Cables, Section 26 27 26 – Wiring Devices, Section 26 05 53 –

Identification for Electrical Systems, Section 26 36 23 – Automatic Transfer Switches, and Section 26 24 16 – Panelboards.

## **1.02 CODES AND STANDARDS**

- A. The packaged engine-generator system shall comply with the following Codes and Standards as a minimum:
1. NEMA MG1 – Motors and Generators.
  2. NEMA MG2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Motors and Generators.
  3. ISO STD 8528 – Reciprocating Internal Combustion Engines.
  4. ISO STD 3046 – Performance Standard for Reciprocating Internal Combustion Engines.
  5. NFPA 30 – Flammable and Combustible Liquids Code.
  6. NFPA 37 – Standard for Installation and use of Stationary Combustible Engine and Gas Turbines.
  7. NFPA 70 – National Electrical Code
  8. NFPA 70E – Standard for Electrical Safety in the Workplace
  9. NFPA 110 – Standard for Emergency and Standby Power Systems.
  10. UL 508 – Industrial Control Equipment.
  11. EGSA – Electrical Generating Systems Association.
  12. UL 2200 – Stationary Engine Generator Assemblies
  13. ANSI C57 – Dry-Type Transformers.
  14. UL 142 – Steel Aboveground Tanks for Flammable and Combustible Liquids.
  15. UL 1236 – Standard for Battery Chargers for Charging Engine Starter Batteries.

## **1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
1. Shop Drawings

2. Spare Parts List
3. Reports of Certified Shop and Field Tests
4. Operation and Maintenance Manuals
5. Manufacturer's Field Start-up Report
6. Manufacturer's Representative's Installation Certification

B. Each submittal shall be identified by the applicable specification section.

#### **1.04 SHOP DRAWINGS**

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for each engine-generator set shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this specification section.
2. Manufacturers printed specification sheets showing critical engine and generator set specifications including the following:
  - a. Dimensions, and weights
  - b. Guaranteed fuel consumption at 25%, 50%, 75% and 100% of full rated load
  - c. Engine bhp available
  - d. Brake Mean Effective Pressure (BMEP)

- e. Engine jacket water heat rejection
  - f. Exhaust flow rate and temperature at 100% of rated load
  - g. Ventilation and combustion air requirements
  - h. Exhaust backpressure limitation
  - i. Liquid refill capacities
  - j. Voltage regulation characteristics
  - k. Guaranteed noise levels
3. Alternator technical electrical data, including, but not limited to:
- a. Alternator efficiency at 50%, 75%, and 100% load
  - b. Telephone Interference Factor (TIF)
  - c. Harmonic waveform distortion
  - d. Type of winding insulation and generator temperature rise
  - e. Per unit subtransient impedance  $X''$  and X/R ratios for positive, negative, and zero sequences
  - f. Transient reactance ( $X_d'$ )
  - g. Synchronous reactance ( $X_d$ )
  - h. Sub transient time constant ( $T_d''$ )
  - i. Transient time constant ( $T_d$ )
  - j. DC time constant ( $T_{dc}$ )
  - k. Decrement curve
4. Manufacturer's printed warranty statement of the engine and generator set showing single source responsibility by the engine manufacturer.
5. Generator control panel equipment and features. Include a written explanation of the auto start/stop logic and operation.
6. Engine-generator set and accessory product data sheets including, but not limited to, the following:
- a. Alternator strip heater

- b. Radiator
  - c. Seismically rated vibration isolators
  - d. Flexible exhaust coupling
  - e. Exhaust silencer
  - f. Batteries
  - g. Battery charger
  - h. Engine manufacturer's shutdown contactors
  - i. Jacket coolant heater
  - j. Fuel cooler
  - k. Fuel tank(s) and pump(s)
  - l. Fuel level devices
  - m. Output circuit breaker and trip unit
  - n. Conduit
  - o. Wire and Cable
7. Standard dealer preventative maintenance contract for review and possible adoption under a separate contract. Dealer must have existing contracts and personnel and contractual detailed performance information available.
  8. Normal operating ranges for systems temperature, pressure and speed.
  9. Manufacturer's part number for the engine and generator operation guide, parts book, service manual, warranty policy, and installation guide.
  10. Location of other similar units showing compliance with the experience requirements specified herein.
  11. Phone numbers of twenty-four (24) hour products support contacts and locations.
  12. Drawing showing right hand, left hand, and top views of proposed assembly; battery rack, isolators, exhaust silencer, conduit stub up locations, and flexible fittings; wiring schematics, interconnection diagrams (point to point), and written description of engine generator controls and alarm circuits.
  13. Control panel layout drawings and wiring diagrams.

14. EPA Certificate of Conformity for Exhaust Emissions
  15. Drawings and specifications for base-mounted fuel storage tank with accessories and leak detection system.
  16. Detailed drawings showing plan, front, and side views as well as appropriate section views of the weatherproof, engine-generator enclosure. Include product data sheets for all appurtenances (e.g. exhaust fan, thermostat, lighting, switches, receptacles, combination power unit, etc.) to be furnished and installed in the enclosure. Drawings shall be of sufficient detail to assure proper installation by the Contractor.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

#### **1.05 REPORTS OF CERTIFIED SHOP AND FIELD TESTS**

- A. Submit two (2) certified copies of all test reports. This includes all shop tests and field tests. Certified shop test reports for prototype engine-generator sets are unacceptable. The manufacturer's serial number for the actual engine-generator set furnished for this project shall appear on all test reports.

#### **1.06 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:
  1. Instruction books and/or leaflets.
  2. Recommended spare parts list.
  3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process.
- B. Manuals shall contain complete information in connection with assembly, operation, lubrication, adjustment, wiring diagrams and schematics, maintenance, and repair, including detailed parts lists with drawings or photographs identifying the parts. Manuals shall contain all information submitted as part of the shop drawing review process.

#### **1.07 SPARE PARTS**



- A. Routine maintenance and adjustments shall be performed without the use of special tools or instruments. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.
- B. In addition to the manufacturer recommended spare parts, the Contractor shall furnish the following spare parts for each engine-generator set:
  - 1. One (1) set of fuel oil particulate filters
  - 2. One (1) set of air filters
  - 3. One (1) set of lubrication oil filters
  - 4. One (1) set of fuel/water separator filters
  - 5. One (1) set of coolant filters
- C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- D. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.
- E. Spare parts list, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- F. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.
- G. The dealer shall have sufficient parts inventory to maintain over-the-counter availability of at least 90% of any required part and 100% availability within 48 hours.

#### **1.08 IDENTIFICATION**

- A. Each engine-generator set shall be identified with the identification name/number indicated on the Drawings (e.g., GEN). A nameplate shall be securely affixed in a conspicuous place on the generator main circuit breaker or output termination box enclosure. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

#### **1.09 WARRANTY TERMS**

- A. The manufacturer's and Dealer's warranty shall in no event be for a period of less than two (2) years or five-hundred (500) hours of operation, whichever comes first, from date

of delivery of equipment to the project site and shall include repair labor, travel expense necessary for repairs at the jobsite, and expendables (lubricating oil, filters, coolant, and other service items made unusable by the defect) used during the course of repair. Submittals received without written warranties as specified shall be rejected in their entirety.

- B. Provided warranty shall cover all equipment included in the scope of supply. This warranty shall include, but is not limited to, the following:
  - 1. Engine-generator set and respective auxiliary equipment
  - 2. All controls for the engine-generator set
- C. Batteries shall be provided with two (2) year full replacement guarantee, and a 48-month pro-rated replacement schedule thereafter.

#### **1.10 OIL SAMPLING KIT**

- A. The generator set supplier shall provide an oil sampling analysis kit which operating personnel shall utilize for scheduled oil sampling. All equipment needed to take oil samples shall be provided in a kit and shall include the following:
  - 1. Sample extraction gun
  - 2. Ten (10) Bottles
  - 3. Ten (10) Postage-paid mailers
  - 4. Written instructions
- B. An additional oil sampling kit shall be made available to the Owner to continue the sampling when the above specified kit has been depleted. All kits in addition to that specified above shall be at an additional cost to the Owner, if the Owner desires to continue the sampling service.

#### **1.11 PREVENTIVE MAINTENANCE AGREEMENT (NOT USED)**

### **PART 2 – PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

- B. The engine-generator set manufacturers shall be Cummins or Caterpillar. No substitutions shall be permitted. The engine-generator set manufacturer and/or dealer shall be responsible for the entire engine-generator package including the engine-generator set with all accessories and equipment specified herein and all other devices required for a complete and operable system.

## **2.02 GENERAL DESCRIPTION**

- A. The engine-generator set shall be rated as specified herein and as indicated on the Drawings. It shall have the capability to operate at its rating for the duration of any power outage with all accessories including engine running devices, silencer, radiator, cooling fans, fuel system, and all appurtenances complete as it would be installed in the field.
- B. Ratings:
  - 1. 125 kW, 156 kVA at 0.8 PF.
  - 2. Voltage: 480Y/277, three-phase, 4-wire, 60 Hz.
- C. Service Conditions:
  - 1. Altitude: 900 feet above sea level.
  - 2. Atmospheric Pressure: 14.7 psia.
  - 3. Ambient Temperature, Maximum: 110 degrees F.
  - 4. Ambient Temperature, Minimum: 10 degree F
  - 5. Relative Humidity: 40 percent to 100 percent, high humidity.

## **2.03 ENGINE**

- A. The engine shall be diesel, 4 cycle, radiator cooled, and shall be turbocharged having an operating speed of 1800 RPM. Engine shall operate on ASTM D-975 Grade No. 2D S15 ultra-low sulfur diesel fuel. Engines requiring any other fuel type are not acceptable. Fuel pump shall be engine-driven, mechanical, positive displacement type, and shall draft directly from the sub-base fuel tank with no need for a day tank.
- B. The engine will not be acceptable if the design is a conversion of a naturally aspirated engine to which a turbo-blower has been attached, unless the engine is certified by the manufacturer as having been analyzed and redesigned with ample provisions for increased stresses and bearing or heat loads due to increased pressures and rate of heat liberation.
- C. Brake Horsepower (BHP), and Engine-Generator efficiency shall conform with ASME, IEEE and NEMA standards that electrical energy delivered by the machine is within the

minimum certified guaranteed fuel oil consumption rate and evidence that these parameters have been met shall be furnished.

- D. Only engine manufacturers' standard ratings shall be acceptable. No dealer special ratings will be acceptable.
- E. The specified standby kW rating shall be for continuous electrical service during interruption of the normal utility source, per NEMA standards.
- F. Engine speeds shall be governed by an electronic isochronous governor that will sense generator speed and provide accurate load transient correction capability at less than 0.5 percent regulation, from no load to full load generator output.

## **2.04 ALTERNATOR**

- A. The alternator shall conform to NEMA and IEEE standards and be rated as indicated on the Drawings. The alternator shall have a UL 2200 Listing. The alternator shall be brushless, salient pole, 2/3 pole pitch and synchronous for operation at 480VAC, wye connected, as indicated on the Drawings. The alternator shall be capable of delivering 250 SkVA (minimum) at an instantaneous voltage dip of no more than 20% voltage drop.
- B. Laminations and windings shall be designed for minimum reactance, low voltage waveform distortion and maximum efficiency.
- C. The main stator coils shall be random wound. Insulation shall be Class F with a temperature rise of no more than 105 degrees C according to NEMA standards. The insulation system shall be made of epoxies and polyesters which are inorganic compounds and shall prevent fungus growth.
- D. The rotor shall be dynamically balanced and include amortisseur windings to minimize voltage deviations and heating effects under unbalanced load conditions.
- E. Radio interference suppression (both directions) shall be provided in accordance with NEMA and IEEE Standards.
- F. The alternator shall have a brushless, permanent magnet generator (PMG) excitation support system to provide input to the automatic voltage regulator to enable the alternator to support 300% of rated current for 10 seconds to allow fault clearing.
- G. Waveform deviation shall not exceed 5% from true sine wave. The transient response from no load to full load in one step of the engine-generator set shall not exceed a voltage dip of 35%, a frequency dip of 20%, and shall recover to complete steady state performance within 12 seconds for both voltage and frequency. The transient response from full load to no load in one step shall not exceed a voltage overshoot of 7% and shall recover to steady state performance within 3 seconds. Transient performance shall be in accordance with ISO 8528.

- H. The Telephone Influence Factor (TIF) shall be less than 50.
- I. The voltage regulator shall be an adjustable, solid-state, three-phase RMS sensing, volts/hertz type. Voltage regulation shall be a minimum of +/-0.25% from no load to continuous rating. The voltage regulator shall provide +/-10% voltage adjustment. The voltage regulator shall be located within the engine control panel.
- J. An alternator mounted strip heater shall be furnished and installed as part of the system. The strip heater shall be energized to prevent condensation when the engine generator set is not running.

## **2.05 CONTROLS**

- A. Engine generator monitoring and controls shall be mounted in a single NEMA 1 (gasketed) dust-tight enclosure. A suitable accessible terminal strip having all wires properly identified shall be furnished within the enclosure. The control panel shall be mounted at a height of 4'-8" measured from the center of the panel to the equipment pad or enclosure floor.
- B. The control panel shall accept a dry contact input for engine starting from remote locations. The starting and stopping of the engine-generator set shall be initiated through the control panel only. When the engine starts, starting control shall automatically disconnect cranking controls. Three (3) cranking cycles of 15 seconds "ON", 15 seconds "OFF" shall be provided. The starting controls shall prevent re-cranking for a definite time after source voltage has been reduced to a low value, or the three (3) cranking cycles have been reached without a successful start. The automatic engine starting controls shall use industrial rated control type elements throughout, and controls shall have the capability to operate at 50% battery voltage.
- C. Speed sensing shall be provided to protect against accidental starter engagement with a moving flywheel. Battery charging alternation output voltage is not acceptable for this purpose.
- D. A UL 489 Listed generator/exciter field circuit breaker with shunt trip device shall be furnished and installed as part of the engine generator set. Shunt trip shall be activated upon engine-generator fault conditions.
- E. Engine generator monitoring and control shall be provided using a microprocessor-based control panel complete with an LCD display. The devices necessary for automatic starting shall be on the engine and in the engine control panel. Provide a red, mushroom head, emergency stop pushbutton. The following manual control features (minimum) shall be provided on the front of the control panel:
  - 1. Engine control mode switch (Run-Off-Auto)
  - 2. Generator voltage adjust

3. Generator frequency adjust
- F. The following parameters (minimum) shall be shown on the LCD display or otherwise be indicated at the control panel:
1. Engine oil pressure
  2. Coolant temperature
  3. Generator output voltage
  4. Generator output current
  5. Generator elapsed run time
  6. Generator output frequency
  7. Engine run
  8. Engine fail
  9. Low coolant temperature
  10. Pre-high engine temperature
  11. Pre-low fuel level
  12. Engine speed (RPM)
- G. The following events (minimum) shall cause an immediate shutdown of the engine-generator set if it is operating or prevent starting if it is not operating. The specific event that causes the shutdown/prevents starting shall be shown on the LCD display or otherwise be indicated at the control panel. A reset shall be required to clear the fault and allow the unit to operate:
1. Engine coolant high temperature
  2. Engine low oil pressure
  3. Low fuel level
  4. Engine overspeed
  5. Engine overcrank
  6. Engine tried to start but failed
  7. Low coolant level

- H. The generator control panel shall have a communication port capable of transmitting all available engine-generator set data via Modbus RTU protocol.
- I. The generator control panel shall have Form C dry contacts rated 5A (minimum) at 120VAC/24VDC for the following signals:
  - 1. Engine coolant high temperature
  - 2. Engine low oil pressure
  - 3. Pre-low fuel level
  - 4. Low fuel level
  - 5. Engine overspeed
  - 6. Engine overcrank
  - 7. Engine tried to start but failed
  - 8. Low coolant level
  - 9. Engine fail
  - 10. Engine run
- J. The normally closed (NC) contacts for all of the above signals (except engine run and Pre-low fuel level) shall be wired in series to provide a common "Generator System Failure" alarm for remote indication. Other contacts shall also be wired as a part of this alarm as specified elsewhere herein.

## **2.06 OUTPUT CIRCUIT BREAKERS**

- A. Provide two main line circuit breakers as specified herein and sized as indicated on the Drawings, one shall feed the load bank connection box and one shall feed the automatic transfer switch. The breakers shall be installed as a load circuit interrupting and protection device in NEMA 1 (gasketed) dust-tight enclosures. Circuit breakers shall be UL 489 Listed and shall have an interrupting rating that is at least 10% greater than the maximum short circuit current available from the generator. Circuit breakers shall be 100% rated where indicated on the Drawings. Key interlock the breakers to prevent simultaneous closure.
- B. The circuit breaker shall be provided with an adjustable electronic trip unit. The trip unit shall be provided with adjustable long-time, short-time, ground fault, and instantaneous settings. It shall operate both manually for normal operation and automatically for protection against overload or short circuits. Generator/exciter field circuit breakers are not acceptable for this service.

## **2.07 ENGINE ACCESSORIES**

- A. Furnish and install the engine with all accessory equipment and appurtenances which are required for proper operation, including the following:
  - 1. Heavy duty dry type air filter with restriction indicator
  - 2. Heavy duty lubricating oil filter, bypass type, with replaceable absorbent-type elements
  - 3. Lubricating oil cooler, water cooled
  - 4. Heavy duty fuel oil filter, spin-on, with non-replaceable absorbent-type elements
  - 5. Fuel oil fuel/water separator
  - 6. Heavy duty crankcase vapor coalescer
  - 7. Radiator mounted fuel cooler to cool recirculated fuel before it is re-deposited into the fuel tank as recommended by the manufacturer.

## **2.08 MOUNTING**

- A. Couple the engine and generator together through a flexible, non-backlash type, all metal coupling which overcomes all normal misalignment stresses and transmits full engine torque with ample safety factor. Also provide flexible connections for piping connections.

## **2.09 COOLING SYSTEM**

- A. Provide a radiator manufactured of a non-corrosive material mounted on the engine. The radiator core shall be coated with a corrosion resistant coating. Corrosion resistant coating shall be a corrosion resistant baked phenolic coating or similar.
- B. Connect the radiator to the engine internal cooling system with flexible piping. Furnish appropriately sized coolant expansion tank for the cooling system.
- C. The engine shall be cooled through a radiator sized to continuously maintain safe operation at full load and at 105°F outside ambient air with 50% ethylene glycol coolant. A blower type fan and low noise fan drive and controls shall be furnished. The fan and all rotating members and drive belts shall be guarded and meet OSHA standards. Proof of 105°F ambient temperature capability shall be required.
- D. Coolant
  - 1. After the cooling system is flushed and cleaned, provide an initial fill of coolant consisting of 50% ethylene glycol. An anti-corrosion treatment shall be added during the initial fill.



2. The coolant shall meet the requirements of the generator manufacturer including corrosion inhibitors provided in the coolant to protect the engine cooling system.
- E. The engine shall be equipped with coolant heaters. Heaters shall be in accordance with the following:
1. Unit mounted thermal circulation type coolant heater with coolant recirculation pump shall be furnished to maintain engine jacket coolant temperature as recommended by manufacturer in an ambient temperature of minus 20°F. The heater shall be 208 VAC, 60 hertz, 3-phase, thermostatically controlled.
  2. The heater shall be of sufficient capacity to keep the coolant at a suitable temperature for trouble-free starting.
  3. Each heater shall be provided with a suitable contactor to automatically disconnect the heater when the engine is started.

## **2.10 ENGINE STARTING AND CHARGING SYSTEM**

- A. Engine starting batteries shall be sealed, lead-acid type, rated 12 volts, wired for 12V or 24V starting. Starting batteries shall have adequate capacity for rolling the engine for five (5), fifteen (15) second cycles without starting, and then operating the control devices in the local generator for two (2) hours. The batteries shall be mounted on a suitable non-corrosive rack which is provided with a battery heating pad that operates at 120VAC or 208VAC. Batteries shall have battery cables with lugs and shall be provided with lugs for connection to the battery charger.
- B. Battery charger shall be a U.L. 1236 listed, automatic, solid-state battery charger, 20 A (min.) current limited,  $\pm 2\%$  voltage regulation,  $\pm 10\%$  line voltage variation, automatic float equalizing system, DC voltmeter, and DC ammeter. Provide a Form C unpowered (dry) contact to indicate a low battery alarm condition.
- C. In addition, the engine shall be provided with an engine battery charging alternator that automatically charges the starting batteries during engine operation.

## **2.11 EXHAUST SILENCER**

- A. Furnish and install an exhaust silencer. Silencers shall be of critical type and sized to produce a high degree of silencing. Reference the sound attenuation requirements specified herein.
- B. Silencer shall be mounted within or exterior to the generator enclosure dependent on generator size and manufacturers standards. Silencers mounted on the outside of the enclosure shall be 316 stainless steel construction on its interior and exterior. Silencers mounted within the generator enclosure shall be painted steel and insulated using a calcium silicate material covered by a brushed aluminum skin.

- C. Connect the silencer to the engine exhaust manifold with a high corrosion and temperature resistant stainless steel flexible convoluted exhaust pipe. Use flange-type connections. Provide a taper-cut tail pipe complete with rain cap to exhaust the gases to the atmosphere. The silencer system shall be designed, furnished, and installed to prevent moisture and condensation from corroding the silencer. All exterior components of the exhaust system shall be made of 316 stainless steel.
- D. The silencer (if installed inside), exhaust piping, and expansion fittings, including collector box, shall be completely covered with a removable insulation blanket in order to protect operating personnel and to reduce noise. Insulation shall be of composite fiberglass and stainless steel construction capable of withstanding 1200°F continuously. The insulation blankets shall be tailored and custom fabricated to fit the contours of the manifolds. Average weight of the insulating blanket shall be 1.5 psf. Insulation shall conform to MIL-1-16411D, Type II and shall be custom fabricated to fit the contours of the components.

## **2.12 WIRING**

- A. Furnish and install internal wiring in the engine-generator set. All internal wiring between the generator and engine-generator control panel, the on-board power source and all accessories shall be provided.

## **2.13 AUTOMATIC TRANSFER SWITCH**

- A. Furnish and install an automatic transfer switch as indicated on the Drawings and specified in Section 26 36 23 – Automatic Transfer Switches. The switch and its operation shall be considered to be part of the standby generator system.

## **2.14 BASE MOUNTED FUEL TANK**

- A. The generator set shall be supplied with a U.L.-142 listed base mounted fuel tank of sufficient capacity to operate the engine-generator set at full load for a minimum of 48 hours. The tank, painted in a color as selected by the Owner, shall be fabricated from steel with a rupture basin and leak detection system. The alarm and indicator for the leak detection shall be mounted adjacent to the generator control panel and a contact for remote indication of a fuel leak condition shall be provided. This contact shall be wired as part of a common "Generator System Failure" alarm.
- B. A level device shall also be furnished and installed to provide a local (generator control panel) and remote indication of pre-low fuel tank level and low fuel tank level. The pre-low fuel tank level shall activate a set of dry contacts for remote alarm indication. The low fuel tank level alarm shall shut down the engine to prevent the fuel level from dropping below the fuel pickup piping in the fuel tank. The pre-low fuel level alarm shall activate when only 12 hours of fuel for full load operation remains in the fuel tank. The remote low fuel tank level alarm shall be wired separate from the "Generator System Failure" alarm. A separate level device shall be furnished and installed to provide an

analog remote indication of the fuel level in the tank. Level device shall have a 4-20mA output.

- C. The tank shall be supplied with all necessary fuel supply, return, vent, and fill fittings and a fuel level gauge. The lockable fill port and level gauge shall be easily accessible from outside the enclosure. Provide a valve that automatically closes the fuel fill inlet when the tank level reaches 95% of its capacity. The vent line shall be piped to the outside and be equipped with a fill whistle. Four (4) spare 2-inch (minimum) ports shall be provided on top of the tank for future use, two (2) on each long side of the generator.
- D. Fuel tank shall be equipped with the necessary hardware, ports, and penetrations to interface with a portable fuel polishing system. Provide ports on each end of the tank (opposing corners). Provide an additional port for fuel siphoning.
- E. Ship the tank with a vacuum pulled and include a pressure gauge to verify that the tank successfully holds a vacuum throughout the shipping process.
- F. The underside of the tank shall not be in contact with the mounting surface (concrete pad).

## **2.15 WEATHERPROOF ENGINE - GENERATOR ENCLOSURE**

- A. Furnish and install an outdoor, weather-protective housing. The housing shall be furnished complete with a full sub-base floor resulting in complete enclosure. The enclosure shall be factory-assembled to the engine-generator set base and radiator cowling. Lifting eyes shall be provided. Housing shall provide ample airflow for generator set operation. The housing shall be constructed of 12-gauge (minimum) aluminum or 14 gauge (minimum) galvanized steel, reinforced to be vibration free in the operating mode. The housing shall have hinged side-access doors and rear control panel access door. Each door shall have at least two latch-bearing points. All doors shall be lockable. All steel sheet metal shall be primed for corrosion protection and finish painted in a color as selected by the Owner. Roof shall be peaked to allow drainage of rain water. Unit shall have sufficient guards to prevent entrance by small animals. Batteries shall fit inside enclosure and alongside the engine (batteries under the generator are not acceptable). Unit shall have engine coolant and oil drains piped to outside the unit to facilitate maintenance. Each drain line shall have a valve located near the fluid source.
- B. A "Skin-tight" housing shall be provided. No walk-around access is required within the enclosure; however, adequate working clearance shall be provided as required by the NEC. Alternatively, access doors may be provided so that when opened, adequate working clearance is achieved in front of electrical equipment.
- C. Enclosure shall be sound attenuated to provide sound level as specified herein.
- D. The enclosure accessories specified herein and indicated on the Drawings (e.g. alternator mounted space heater, battery charger, leak detection system, etc.) that require "shore power" will be supplied from the Owner's distribution system. The

enclosure manufacturer shall furnish and install conduit and wire necessary to provide the power from a shore power junction box to all accessories.

- E. Provide a load bank connection cabinet to facilitate connection of a portable load bank to the generator output terminals.
  - 1. Ratings: 200A, 480/277V, 3-phase, 4-wire.
  - 2. NEMA 3R for flush mounting on genset weather-proof enclosure wall.
  - 3. Factory connected to generator output breaker.
  - 4. Provide UL type W, single conductor cables. Cables shall be 50 feet long unless otherwise shown on the Drawings. The generator end of the cables shall be provided with color coded cam-lock connectors matched to the connection cabinet's receptacles.
  - 5. Equal to Trystar, Inc., Generator Docking Station.
- F. All hardware (nuts, bolts, screws, washers, etc.) that is installed on the exterior of the generator enclosure shall be stainless steel. Galvanized steel hardware is not acceptable.
- G. Aluminum stairs and aluminum handrail shall be furnished at each door. The Contractor shall extend the generator concrete pad as necessary to accommodate the installation of the aluminum stairs.
- H. Conduit and wire shall be in accordance with Sections 26 05 33.13 – Conduit for Electrical Systems and Section 26 05 19 – Low-Voltage Conductors and Cables, respectively.
- I. All air intake louvers shall be furnished with rain guards or designed to eliminate water intrusion to the interior of the enclosure when the generator is operating at full load (maximum airflow) during rain events.

## **2.16 SOUND ATTENUATION**

- A. Extreme care shall be exercised in providing equipment for and setting the engine-generator in place to guard against excessive noise transmission and vibrations. Fasten to the underside of the skids seismically-rated spring type isolators.
- B. The engine-generator enclosure shall be designed, furnished, and installed to reduce source noise to 85 dB(A) as measured at seven (7) meters from the enclosure.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. The standby generator system shall be furnished and installed as indicated on the Drawings and as recommended by the equipment manufacturer.
- B. The initial filling of the fuel storage tank shall be provided by the Contractor. Fuel tank shall be filled to its full capacity. At the conclusion of all field testing, the Contractor shall fill the fuel storage tank back to its full capacity. Fuel shall be ultra-low sulfur diesel Grade No. 2D S15 in accordance with ASTM D-975. Fuel shall be new and free from contaminants and water.

### **3.02 SERVICES OF MANUFACTURER'S REPRESENTATIVE**

- A. The Contractor shall provide the services of a qualified generator manufacturer's factory-trained technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.
- B. The manufacturer's technical representative shall perform all startup and field testing of the generator assembly as specified herein.
- C. The Contractor shall provide training for the Owner's personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner's personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the generator has been installed and tested. Training shall be conducted at times coordinated with the Owner and shall occur during the same week as the training specified in Section 26 36 23 – Automatic Transfer Switches.
- D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:
  - 1. One (1) trip of two (2) working days during installation of the engine-generator set.
  - 2. One (1) trip of one (1) working day to perform startup of the engine-generator set.
  - 3. One (1) trip of one (1) working day to perform the field testing of the engine-generator set.
  - 4. One (1) trip of one (1) working day to perform training as specified herein.
  - 5. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify issues to be corrected under warranty. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

### 3.03 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
1. Witnessed Shop Tests
    - a. None required.
  2. Certified Shop Tests
    - a. Fully test the engine-generator set with all accessories in the manufacturer's plant before shipment.
    - b. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure.
    - c. Generator load tests shall be conducted through the use of balanced, three-phase, dry-type, reactive (0.8 power factor) load banks. Conduct a continuous run test using the load bank without shutdown for the engine-generator set under the following load conditions (in this specific order):
      - d. 3 hours - full load
      - e. 1 hour - 3/4 load
      - f. 1 hour - 1/2 load
      - g. 1 hour - 1/4 load
    - h. Fuel, lubricants, and other fluids as required for the shop tests shall be furnished by the manufacturer.
  3. Field Tests
    - a. Field tests shall be performed by the generator manufacturer's technical representative. The Contractor shall obtain from the manufacturer and submit a detailed field test plan and procedures documenting the intended field test program.
    - b. In the presence of the Engineer and Owner, the representative shall inspect, adjust, and test the entire system after installation and leave in good working order. Field tests specific to each generator shall be conducted after the entire engine-generator system is installed including, but not limited to, the following: diesel fuel tanks including leak detection, exhaust silencer, radiators, enclosures, batteries, and all other equipment included in the complete system.

- c. Field test the generator enclosure to ensure the enclosure performs as specified herein. The generator enclosure field tests shall include water tests to confirm the enclosure does not leak and that the air intake louvers eliminate water intrusion to the interior of the generator enclosure when the generator is operating at its full load capacity (maximum airflow). A garden hose shall be used to simulate falling rain for this test. Water supply and garden hose will be provided by the Owner for this test.
- d. Field test, as far as practicable, all control, shutdown, and alarm circuits. Document the successful completion of these tests as witnessed by the Owner and the Engineer.
- e. Generator load tests shall be conducted through the use of balanced, three-phase, dry-type, reactive (0.8 power factor) load banks. Conduct a continuous run test using the load bank without shutdown for the engine-generator set under the following load conditions (in this specific order) and in the presence of the Owner and Engineer:
  - 1) 5 hours, full load
  - 2) 1 hour, 3/4 load
  - 3) 1 hour, 1/2 load
  - 4) 1 hour, 1/4 load
- f. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure every 15 minutes during the continuous run test. If any failures, malfunctions, and/or shutdowns occur during this test, the problems shall be fixed and the test shall be restarted. The test shall not be considered complete until the generator has operated without any shutdowns for the required consecutive hours under the conditions listed above.
- g. After successful completion of the load bank tests, the generator system shall then be operated for a minimum of four (4) hours with facility loads during a time period when the plant is operating at average demand. The same data shall be recorded at 15-minute intervals for this load test as for the load bank test.
- h. It is the intent that the tests above take place utilizing facility loads. If the system cannot be fully loaded as required by the facility loads, the manufacturer shall connect a reactive load bank to a spare circuit breaker in the switchgear as needed to test the system under the loads described above. If any failures, malfunctions, and/or shutdowns occur during any of the transfer tests listed above, the problems shall be fixed and the test shall be restarted. Each test shall not be considered complete until the

generator/switchgear system has performed the required number of transfers consecutively without any failures or malfunctions. During the transfer testing above, the loads shall remain on the utility or generator source for at least five (5) minutes in between transfers.

- i. All fuel, lubricants, and other fluids required to complete all field tests shall be paid for by the Contractor.

#### 4. Oil Sampling and Analysis

- a. The Contractor shall collect a sample of engine oil from each engine for analysis after the start-up and testing has been successfully completed. The oil samples shall be analyzed at an independent laboratory that is not a part of the engine supplier's facility. Immediate notification of results shall be provided to the Owner when the analysis shows any critical reading.
- b. The sampling method shall be of the atomic absorption spectrophotometry method and be accurate to within a fraction of one part per million for the following elements:
  - 1) Iron
  - 2) Chromium
  - 3) Copper
  - 4) Aluminum
  - 5) Silicon
  - 6) Lead
- c. The sample shall also be tested for the presence of water, fuel dilution, and coolant.

### 3.04 PAINTING

- A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

**END OF SECTION**



**SECTION 26 36 23**  
**AUTOMATIC TRANSFER SWITCHES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, connect, test and place in satisfactory operation automatic transfer switches as specified herein and indicated in Drawings.
- B. All devices and components of the automatic transfer switch shall be NEMA rated. IEC rated devices are unacceptable and shall be cause for rejection of the submittals/equipment.

**1.02 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings
  - 2. Operation and Maintenance Manuals
  - 3. Spare Parts Lists
  - 4. Special Tools List
  - 5. Reports of certified shop tests shall be submitted which indicates a closing and withstand ampere rating as required based on short circuit study requirements. Rating shall be symmetrical, 3 cycles at 480 VAC.
  - 6. Guarantee/Warranty Program
- B. Each submittal shall be identified by the applicable specification section.

**1.03 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.
- C. Shop drawings for each automatic transfer switch shall include but not be limited to:

1. Product data sheets.
  2. Complete assembly, layout, and installation drawings with clearly marked dimensions and conduit entrance locations.
  3. Example equipment nameplate data sheet.
  4. Complete internal schematic and interconnecting wiring diagrams.
  5. Nameplate schedule.
  6. Manufacturer's standard installation instructions.
  7. Manufacturer's standard warranty.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.
- E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each automatic transfer switch. These final drawings shall be plastic laminated and securely placed inside each transfer switch and included in the O&M manuals.

#### **1.04 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

#### **1.05 TOOLS, SUPPLIES AND SPARE PARTS**

- A. The automatic transfer switches shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.
- B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.
- D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

- E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

#### **1.06 WARRANTY TERMS**

- A. The manufacturer shall warrant each automatic transfer switch for a minimum of five (5) years from date of shipment. In addition, the manufacturer shall repair or replace equipment found faulty under the terms of the warranty. The manufacturer shall submit data outlining the guarantee/warranty program.
- B. The manufacturer shall have an established network of service centers capable of servicing the specified equipment. The manufacturer shall have a service center within 200 miles of the project site which shall stock parts necessary to service the switch. The manufacturer shall include an 800 telephone number for a field service contact affixed to each enclosure.
- C. Service center personnel shall be on call 24 hours a day, 365 days a year. Personnel shall be factory-trained and certified in the maintenance and repair of the specified equipment.
- D. After-warranty service contracts shall be made available to the Owner by the manufacturer, through the service centers, to provide periodic maintenance and/or repair of the specified equipment.

#### **1.07 IDENTIFICATION**

- A. Each automatic transfer switch shall be identified with the identification number indicated on the Drawings (e.g. ATS-1, ATS-2, etc.). A nameplate shall be securely affixed in a conspicuous place on each switch. Nameplates shall be as specified in Section 26 05 53, Identification for Electrical Systems.

#### **1.08 TRAINING**

- A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.
- B. Provide the services of an experienced, factory trained technician or service engineer of the switch manufacturer at the jobsite for minimum of one (1) day for training of Owner personnel, beginning at a date mutually agreeable to the Contractor and the Owner. The technician shall be on duty at the site for at least 8 hours per day and shall be available 24 hours per day when required to advise concerning special problems with equipment and systems.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The equipment described herein, as a minimum, shall meet all of the requirements specified in this Section and shall be a product of a manufacturer who has produced automatic transfer switches for a period of at least five (5) years. The equipment shall be compatible with the loads to be served. Assembly of the switches by a fabricator is not acceptable.
- C. The manufacturer of the automatic transfer switch shall verify that the switches are listed by Underwriters Laboratories, Inc., standard UL-1008, with 3-cycle withstand and close-in values as indicated on the Drawings or specified herein.
- D. The automatic transfer switches shall be as manufactured by Eaton, ASCO, or Russelectric; no substitutions.

### **2.02 AUTOMATIC TRANSFER SWITCH**

- A. General
  - 1. Switches shall have ampere ratings and number of poles as indicated on the Drawings and shall be suitable for 480 VAC, three-phase, 60 Hertz operation.
  - 2. Provide a neutral lug for three phase, four-wire systems where a neutral is required.
  - 3. The transfer switch shall be housed in a NEMA 1 (gasketed) enclosure fabricated from 12-gauge steel suitable. The enclosure shall exceed the UL-1008 minimum wire bending space requirements. The enclosure shall be equipped with an internal, welded steel, door-mounted print pocket.
  - 4. The transfer switch shall have both top and bottom mounted cable access.
  - 5. The switch shall be capable of switching all classes of load and rated for continuous duty when installed in a non-ventilated enclosure.
  - 6. The three-cycle closing and withstand current rating of the switch shall be 42,000 amperes RMS (minimum).
  - 7. This switch shall be complete with all accessories and listed by UL under Standard UL-1008 for use on emergency systems.

8. All bolted bus connections shall have Belleville compression type washers. Switches for four-wire systems shall be furnished with a fully rated solid neutral bus.
9. The switch shall be equipped with 90°C rated copper/aluminum solderless mechanical type lugs of the proper quantity and size to accommodate the termination of field wiring.
10. Switches shall be capable of normal operation during and after seismic loading. Seismic loading shall not cause false operation.

#### B. Design Requirements

1. Switches shall be electrically operated, mechanically held, double-throw with ampere ratings and number of poles as indicated on the Drawings and shall be suitable for 480 VAC, three-phase, 60 Hertz operation. A center-off-position shall be provided as a neutral position during switching. Minimum transfer time shall 400 milliseconds.
2. Switches shall be capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.
3. The time delay between the opening of the closed contacts and the closing of the open contacts shall allow for voltage decay before transfer, allowing the motor and transformer loads to be re-energized after transfer with normal in-rush current. Switches using in-phase monitors are not acceptable.
4. Normal and standby contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts to be of silver-tungsten alloy, mechanically locked in position in both the normal and standby positions without the use of hooks, latches, or magnets. Provide separate arcing contacts, with magnetic blowouts on each pole. Main and arcing contacts shall be visible when door is open and barrier covers removed.
5. Equip the transfer switch with a permanently attached, safe, manual operator designed to prevent injury to personnel in the event the electrical operator should become energized during manual transfer. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from slowly switching the main contacts.

#### C. Sequence of Operation

1. Should the voltage on any phase of the normal source drop below 80 percent or increase to 120 percent, or frequency drops below 90 percent, or increase to 110 percent, or 20 percent voltage differential between phases occur, after a programmable time delay period of 0-9999 seconds factory set at three (3)

seconds to allow for momentary dips, the engine starting contact(s) shall close to start the standby engine generator.

2. Transfer to the standby power source shall occur when 90 percent of rated voltage and frequency has been reached by the standby power source.
3. After restoration of normal power on all phases to a preset value of 90 percent to 110 percent of rated voltage, at least 95 percent to 105 percent of rated frequency, and voltage differential is below 20 percent between phases, an adjustable time delay period of 0-9999 seconds factory set at 300 seconds shall delay the transfer to allow stabilization of the normal source. Should the standby source fail during this time delay period, the switch shall automatically retransfer to the normal source.
4. After retransfer to the normal power source, the standby engine generator shall operate at no load for a programmable period of 0-9999 seconds factory set at 300 seconds. Should the normal power source fail during this time delay period, the transfer switch shall automatically return to the standby source.

#### D. Controls

1. The transfer switch shall be equipped with a microprocessor-based control system to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with NiCad battery back-up.
2. The CPU shall be equipped with self-diagnostics which perform periodic checks of the memory, I/O, and communication circuits with a watchdog power fail circuit.
3. The controller shall use industry standard open architecture communication protocol for high speed serial communications via multidrop connection to other controllers and to a master terminal with up to 4000 ft of cable, or further with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.
4. The serial communication port shall allow interface to either the manufacturer's or the Owner's furnished remote supervisory control system.
5. The controller shall have password protection to limit access to authorized personnel.
6. The controller shall include a 20 character LCD display with a keypad, which allows access to the system.
7. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection, and phase differential monitoring on both normal and standby sources.

8. The controller shall be capable of storing the following records in memory for access either locally or remotely:
  - a. Number of hours the transfer switch is in the standby position (total since record reset).
  - b. Number of hours standby power source is available (total since record reset).
  - c. Total transfer in either direction (total since record reset).
  - d. Date, time, and description of the last four source failures.
  - e. Date of the last exercise period.
  - f. Date of record reset.
9. Light emitting diodes shall be mounted on the controller to indicate:
  - a. Switch is in normal position
  - b. Switch is in standby position.
  - c. Controller is running.
10. A three-phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase-to-phase voltages simultaneously for both the normal and standby source.
11. A digital LCD frequency readout with 1% accuracy shall display frequency for both the normal and standby source.
12. An LCD readout shall display both normal source and standby source availability.
13. The microprocessor controller shall meet the following requirements:

Storage conditions:	25°C to 85°C
Operation conditions:	20°C to 70°C ambient
Humidity:	0 to 99% relative humidity, non-condensing
Capable of withstanding infinite power interruptions	
Surge withstand per ANSI/IEEE C-37.90A-1978	

14. All control wiring shall be 18 gauge (minimum), 600 VAC, SIS switchboard type. All control wiring shall be identified at each termination (both ends) using tubular, sleeve-type wire markers.
15. The automatic transfer switch controller shall be a Model ATC-600 IQ transfer device as manufactured by Cutler-Hammer, or ASCO and Russelectric equals. The controller shall be programmed by the manufacturer at the factory.

#### E. Accessories

1. Programmable three phase sensing of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.
2. Programmable three phase sensing of the standby source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.
3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds.
4. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.
5. Time delay on transfer to standby, programmable 0-9999 seconds, factory set at 3 seconds.
6. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.
7. A time delay bypass on retransfer to normal shall be included. Keypad initiated.
8. Contact, rated 10 A at 30VDC, to close on failure of normal source to initiate engine starting.
9. A plant exerciser shall be provided with (10) 7 day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise the standby plant programmable in one minute increments.



Also include a control switch for selection of either "no load" (switch will not transfer) or "load" (switch will transfer) during the exercise period. Keypad initiated.

10. Relay contacts which close when normal source fails wired to a terminal strip.
11. Relay contacts which open when normal source fails wired to a terminal strip.
12. Two auxiliary contacts rated 15 A at 120 VAC on main shaft, closed on normal and wired to a terminal strip.
13. Two auxiliary contacts rated 15 A at 120 VAC on main shaft, closed on standby and wired to a terminal strip.

### **2.03 PAINTING**

- A. Finish coat shall be ANSI #61.
- B. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Each automatic transfer switch shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.
- B. The automatic transfer switch shall be provided with adequate lifting means for installation of wall or floor mounted enclosures.
- C. The Contractor shall tighten all assembled bolted connections to the manufacturer's torque recommendations prior to energizing.
- D. Install each switch to allow complete door swing required for component removal. This is specifically required where a switch is set next to a wall to the left of the switch enclosure.

### **3.02 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  1. Witnessed Shop Tests
    - a. Shall be made available at manufacturing facilities if requested.

## 2. Certified Shop Tests and Reports

- a. Automatic transfer switches shall be given routine factory tests. The factory tests shall demonstrate that the completed switches function correctly and that the required timing has been set. Certification of these settings shall be submitted to the Engineer upon request.
- b. Test procedures shall be in accordance with UL-1008. During the 3-cycle withstand tests, there shall be no contact welding or damage.
- c. The three cycle tests shall be performed without the use of current limiting fuses.
- d. Oscillograph traces across the main contacts shall verify that contact separation has not occurred and there is contact continuity across all phases after completion of the test.
- e. When conducting temperature rise tests in accordance with UL-1008, include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.
- f. Manufacturer shall submit test reports upon request.

## 3. Field Tests

- a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 26 05 00 – Basic Electrical Requirements.
- b. Prior to acceptance of the installation, load test the equipment with all available motor load, but do not exceed the generator's or automatic transfer switch's nameplate rating. Correct defects which become evident during this test.

### **3.03 SERVICES OF MANUFACTURER'S REPRESENTATIVE**

- A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined elsewhere in Division 01 and Section 46 00 00 – Equipment General Provisions. The services of the manufacturer's representative shall be provided for a period of not less than as follows:
  1. One trip of one (1) working day during installation of the equipment for each automatic transfer switch.

2. One trip of one (1) working day after acceptance of the equipment.
  3. One trip of one (1) working day during the warranty period.
- B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Field Representative on each day he is at the project.

**END OF SECTION**

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**SECTION 26 43 13**  
**SURGE PROTECTIVE DEVICES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, and place in satisfactory operation, the surge protective devices (SPD) as specified herein and indicated on the Drawings.
- B. The surge protective devices specified under this Section shall be provided as a stand-alone unit, separate from the enclosure of the equipment to which they are connected. The requirements of this Section shall not apply to equipment where an integral SPD is specified.
- C. Reference Section 26 05 19 – Low-Voltage Conductors and Cables, and Section 26 05 53 – Identification for Electrical Systems.

**1.02 CODES AND STANDARDS**

- A. The surge protective device shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. Underwriters Laboratories, Inc. (UL)
    - a. UL1449, latest edition: Surge Protective Devices
    - b. UL1283, latest edition: Electromagnetic Interference Filters
- B. American National Standards Institute (ANSI)/Institute of Electrical & Electronic Engineers (IEEE)
  - 1. C62.41.1: 2002 Guide for Surge Voltages in Low-Voltage AC Power Circuits
  - 2. C62.41.2: 2002 Recommend Practice on Characterization of Surges in Low Voltage (100V and Less) AC Power Circuits.
  - 3. C62.45: 2002 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits
  - 4. C62.62: 2000 IEEE Standard Test Specifications for Surge Protective Devices for Low Voltage (1000V and Less) AC Power Circuits

### 1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings
  - 2. Operation and Maintenance Manuals
  - 3. Spare Parts List

### 1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for re-submittal.
- C. Drawings submitted by the manufacturer shall be complete and documented to provide the Owner with operations and maintenance capabilities.
- D. Shop drawings for each SPD shall include but not be limited to:
  - 1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.
  - 2. Product Data Sheets.
  - 3. Detailed drawings showing weights and dimensions.
  - 4. Wiring diagrams showing field connections.

5. Proof that all products provided under this Section are UL listed and labeled by Underwriters Laboratories to UL1449, latest Edition. This proof shall be a copy of the data listed under the UL File Number for the manufacturer, which may be obtained from the UL Online Certification Directory. No other means of proving compliance (such as manufacturer data sheets, marketing material, etc) will be considered acceptable.
  6. Proof of Short Circuit Current Ratings (SCCR), Voltage Protection Ratings (VPRs) for all modes, Maximum Continuous Operating Voltage rating (MCOV), Nominal Discharge Current (In), and device listing Type shall be submitted using the same means as described in the paragraph above.
  7. Proof that all products provided under this Section are UL listed and labeled by Underwriters Laboratories to UL 1283, latest Edition. This proof shall be a copy of the data listed under the UL File Number for the manufacturer, which may be obtained from the UL Online Certification Directory. No other means of proving compliance (such as manufacturer data sheets, marketing material, etc) will be considered acceptable.
  8. Warranty Information
- E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "Soft Cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are to provide are acceptable and shall be submitted.

#### **1.05 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

#### **1.06 SPARE PARTS**

- A. All spare parts as recommended by the equipment manufacturer shall be furnished by the Contractor to the Owner.
- B. The Contractor shall furnish one (1) spare field replacement module of each rating provided under this Contract.
- C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

- D. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the Work, at which time they shall be delivered to the Owner.
- E. Spare parts lists, included with the shop drawing submittal shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- F. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same part number.

#### **1.07 IDENTIFICATION**

- A. Each SPD shall be identified by the circuit number and equipment name as indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each SPD. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

#### **1.08 WARRANTY**

- A. All SPDs, associated hardware, and supporting components shall be warranted to be free from defects in materials and workmanship, under normal use and in accordance with the instructions provided, for a period of five (5) years after acceptance of the equipment by the Owner.
- B. Any component or subassembly contained within the surge protection system that shows evidence of failure or incorrect operation during the five (5) year warranty period, shall be replaced by the manufacturer at no additional cost to the Owner.

### **PART 2 – PRODUCTS**

#### **2.01 GENERAL**

- A. The SPD units shall be UL 1449 Listed and must bear the UL mark. Units that are "manufactured in accordance with" UL 1449 or tested by other testing agencies "in accordance with" UL 1449 are not acceptable and will be rejected.
- B. Type II SPD units shall be UL 1283 Listed and must bear the UL mark. Units that are "manufactured in accordance with" UL 1283 or tested by other testing agencies "in accordance with" UL 1283 are not acceptable and will be rejected. Further, SPD units using UL 1283 capacitors but not tested to UL 1283 will be rejected.
- C. SPDs shall be provided as a stand-alone unit, separate from the equipment to which they are connected.



- D. All SPDs furnished and installed under this Contract shall be from the same manufacturer.

**2.02 PRODUCTS**

- A. Type I surge protective devices (SPD) shall be furnished and installed when shown without upstream overcurrent protection on the Drawings. Type II SPDs shall be provided in all other locations. Type II SPDs shall not require the use of a specific upstream overcurrent device. SPDs shall be provided in the location and quantity as shown on the Drawings.
- B. Each SPD shall be rated for the voltage and configuration of the equipment to which it is connected.
- C. Each Type II SPD shall have UL 1283 EMI/RFI filtering with minimum attenuation of - 50dB at 100kHz.
- D. The short circuit current rating of each SPD shall match or exceed the rating of the equipment to which it is connected. The Contractor shall reference the Drawings for short circuit current rating of each piece of equipment.
- E. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

System Configuration	Modes of Protection	Number of Modes
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedance Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

- F. Each SPD shall have a Maximum Continuous Operating Voltage (MCOV) of at least 115% of the nominal voltage of the equipment to which it is connected.
- G. The Nominal Discharge Current (In) of each SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.
- H. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

System Voltage	L-N	L-G	L-L	N-G
208Y/120	800V	800V	1200V	800V
480Y/277	1200V	1200V	2000V	1200V

<b>System Voltage</b>	<b>L-N</b>	<b>L-G</b>	<b>L-L</b>	<b>N-G</b>
480 DELTA	N/A	1800V	2000V	N/A
240 DELTA	N/A	1200V	1200V	N/A
120/240	800V	800V	1200V	800V

- I. The surge current rating for each SPD shall be as indicated on the Drawings. Surge current ratings are indicated on single line diagrams and in panel schedules. Surge current rating indicated is on a per phase basis.
- J. Each SPD shall be provided in an enclosure to match or exceed the NEMA rating of the equipment enclosure that it is serving (i.e. NEMA1, NEMA 12, NEMA 4X, etc).
- K. Each SPD shall be provided with the following accessories:
  - 1. Each individual module shall feature an LED indicating the individual module has all surge protection devices active. If any single component is taken off-line, the LED shall turn off and another LED shall illuminate, providing individual module as well as total system status indication.
  - 2. Surge counter and audible alarm with reset/silence switch.
  - 3. One set of Form C (SPDT) dry contacts rated for at least 5A at 120VAC.
- L. SPDs shall be as manufactured by Eaton, Thor Systems, ASCO/Emerson Network Power, General Electric, or Square D.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. The SPD units shall be furnished and installed as shown on the Drawings and in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.
- B. The SPD units shall be mounted such that the conductor lengths are as short as possible, but no greater than 36 inches. Any installation resulting in a conductor length of greater than 36 inches shall be reviewed with the Engineer as a special type of cable may need to be installed. For equipment such as panelboards, the Contractor shall relocate the circuit breaker that is to be connected to the SPD as needed to achieve the shortest conductor length possible.
- C. The Contractor shall use a close nipple to enclose the conductors between the SPD and the equipment served. However, if due to field conditions a 90 degree conduit bend is required to connect the SPD to the equipment that it serves, the bend shall have a

minimum radius of 36 inches to eliminate any potential for sharp bends in the conductors.

- D. Conductors between the equipment served and the SPD shall be 600V power wire and cable as specified in Section 26 05 19 – Low-Voltage Conductors and Cables. The individual conductors shall be gently twisted and sized as indicated on the Drawings.
- E. Prior to energizing, the Contractor shall verify that the SPD unit voltage and configuration is suitable for the system to which it is connected.
- F. Prior to energizing, the Contractor shall also verify that any Neutral to Ground bonding jumpers are installed as required.
- G. Prior to energizing, the Contractor shall also verify that the impedance of the equipment grounding conductor between the SPD and the grounding electrode system is less than 1 ohm.

### **3.02 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. Shop Tests
    - a. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA, ANSI, and UL standards.
    - b. All surge protective devices, subassemblies, and components shall be 100% tested and certified by the manufacturer to meet their published performance parameters.
  - 2. Field Tests
    - a. None required.

**END OF SECTION**

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**SECTION 26 50 00**  
**LIGHTING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install all lighting fixtures, labor, and material, in accordance with the preceding Specifications, the requirements of this Section, and as shown on the Drawings.
- B. Lighting shall be in accordance with the latest requirements of the Illuminating Engineering Society.
- C. Reference Section 26 05 00 – Basic Electrical Requirements, and Section 26 05 26 – Grounding and Bonding for Electrical Systems.

**1.02 CODES AND STANDARDS**

- A. The equipment specified herein shall comply with the following codes and standards, where applicable.
  - 1. Underwriter’s Laboratories, Inc. (UL):
    - a. UL 924 – Emergency Lighting and Power Equipment
    - b. UL 935 – Fluorescent Lamp Ballasts
    - c. UL 844 – Luminaires for Use in Hazardous (Classified) Locations
    - d. UL 916 – Standard for Energy Management Equipment
    - e. UL 1029 – High Intensity Discharge Lamp Ballasts
    - f. UL 1598 – Luminaires
  - 2. American National Standards Institute (ANSI):
    - a. ANSI C82.11 – High Frequency Fluorescent Lamp Ballasts
    - b. ANSI C62.41 – Guide for Surge Voltages in Low-Voltage AC Power Circuits
  - 3. National Electrical Code (NEC), latest edition.
- B. Where equipment herein is specified as being Listed to a particular UL standard, that equipment shall be tested for compliance with the UL standard by either UL itself,

Factory Mutual (FM), or the Canadian Standards Association (CSA). Testing to UL standards by any other testing agencies is not acceptable.

### **1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
  - 1. Shop Drawings
  - 2. Operation and Maintenance Manuals
  - 3. Spare Parts Lists
- B. Each submittal shall be identified by the applicable specification section.

### **1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.
- C. Shop drawings shall include but not be limited to:
  - 1. Product data sheets.
  - 2. Catalog cuts for each fixture type showing performance and construction details of standard fixtures, and complete working drawings showing all proposed construction details of special or modified standard fixtures.
  - 3. Photometric curves.
  - 4. LED data including efficiency (Efficacy lumens/watt) information.
  - 5. LED Driver information
  - 6. Catalog data including applicable coefficients of utilization tables, isolux chart of illumination on a horizontal plane, beam efficiency, horizontal and vertical beam spread, and beam lumens.
  - 7. Manufacturer's warranty information
  - 8. Custom wiring diagrams for each individual lighting contactor application. Standard wiring diagrams that are not custom created by the manufacturer for the individual

lighting contactors for this project are not acceptable. One wiring diagram which is typical for all lighting contactors is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

9. System (entire fixture assembly) efficiency data.
  10. Pole and foundation calculations.
- D. Shop drawings shall be submitted to the Engineer for review and acceptance for all fixtures before fixtures and poles are manufactured. Substitutions will be permitted only if acceptable to the Engineer.
- E. Manufacturer's model/series and description in the luminaire schedule on the Contract Documents establishes a level of quality, style, finish, etc. The use of a model/series describing the various types of fixtures shall be used as a guide only and does not exclude all the required accessories or hardware that may be required for a complete installation.

#### **1.05 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall submit Operation and Maintenance Manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01.

#### **1.06 SPARE PARTS**

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor. The following additional spare parts shall be furnished:
1. A minimum of one (1) complete fixture for each type installed.
- B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.
- D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

- E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

#### **1.07 LIGHTING CONTROLS**

- A. The lighting systems shall be controlled as specified herein and indicated on the Drawings.
- B. Lighting contactors shall be furnished and installed for specific lighting control applications as specified herein and indicated on the Drawings.

#### **1.08 WARRANTY**

- A. The manufacturer's warranty shall in no event be for a period of less than five (5) years from date of delivery of fixtures to the project site and shall include repair labor, travel expense necessary for repairs at the jobsite, shipping costs, expendables used during the course of repair, or complete replacement of the failed lighting unit.
- B. Warranty for LED fixtures shall be provided for the entire fixture and shall include all parts and accessories. Submittals received without written warranties as specified shall be rejected in their entirety.

### **PART 2 – PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

#### **2.02 FIXTURES**

- A. All lighting fixtures shall be furnished complete w all fittings and hardware necessary for a complete installation. Lighting fixtures shall have all accessories, characteristics, and functionality as specified.
- B. Fixture leads shall be as required by NEC. Fixtures shall be grounded by the equipment grounding conductor in the conduit.
- C. All glassware shall be high quality, homogeneous in texture, uniform in quality, free from defects, of uniform thickness throughout, and properly annealed. Edges shall be well rounded and free from chips or rough edges.
- D. Emergency fixtures shall be UL 924 listed and have a minimum 90 minutes battery back-up.



- E. Fixtures for use in hazardous locations shall be UL 844 Listed.
- F. Fixtures specified to be damp or wet locations rated shall be UL 1598 listed.
- G. Fixtures shall be as specified in the luminaire schedules on the Drawings.

### **2.03 HID FIXTURE BALLASTS (NOT USED)**

### **2.04 FLUORESCENT FIXTURE BALLASTS (NOT USED)**

### **2.05 LED DRIVERS**

- A. Drivers shall have a voltage range of 347-480V or 120-277 (as required) +/- 10% at a frequency 60Hz.
- B. All drivers shall be designed to a power factor >90% with a total harmonic distortion THD <20% at full load.
- C. Case temperature shall be rated for -40°C through +80°C.
- D. Drivers shall have overheat protection, self-limited short circuit protection and overload protected.
- E. Drivers shall be furnished with a fused primary.
- F. Drivers shall have an output current ripple <30%
- G. Drivers shall be manufactured by Advance, Universal or equal.
- H. Drivers shall be UL Listed for damp location, UL1012, UL935, ROHS.
- I. Drivers shall meet FCC 47 Sub Part 15.
- J. All drivers shall be provided with ANSI/IEEE C62.41 Category C (10kV/5kA) surge protection.

### **2.06 LAMPS (NOT USED)**

### **2.07 LEDS**

- A. Luminaires provided with LED technology shall utilize high brightness LEDs with a group binning code of P and/or Q.
- B. Color Temperature: as specified in luminaire schedule.
- C. Junction point shall be designed and manufactured to allow adequate heat dissipation.
- D. LEDs shall be rated for 50,000 hours of life, minimum (based on IESNA L70).

## **2.08 POLES AND FOUNDATIONS**

- A. Poles shall be designed to withstand calculated wind force based on wind velocity in accordance with the provisions of the Building Code for the State in which the project is located.
- B. Pole mounted fixtures shall be mounted on poles as designated in the luminaire schedule or as indicated on the Drawings. Poles shall have adequate handholes. Furnish and install weatherproof receptacles where indicated. All anchor bolts and nuts shall be hot-dipped galvanized steel.
- C. The Contractor shall furnish and install a concrete foundation for the pole mounted fixtures as indicated on the Drawings and as required.
- D. Poles shall be as specified in the luminaire schedule on the Drawings and shall be furnished with the indicated fixture types.

## **2.09 LIGHTING CONTROLS**

- A. Lighting Contactor and Photocell
  - 1. Furnish and install a lighting contactor and photocell combination to control lighting as indicated on the Drawings
  - 2. Lighting contactors shall be as manufactured by Eaton, the Square D Company, General Electric Company, or Siemens Energy and Automation, Inc. Lighting contactors shall be heavy duty industrial type with 30A minimum rating and shall have the number of contacts required. Contactor ampere rating shall be increased as required to suit the application. Contactor coil voltage shall be as indicated on the Drawings. Contactors shall be the electrically or mechanically held type as indicated on the Drawings. Contactors shall include fused integral control power transformers. Any auxiliary relays, or other devices required for proper operation shall be included.
  - 3. Photocells shown on the Drawings that are not integral to a fixture shall be provided by the Contractor. Photocells shall be rated for 120 VAC, 1800W, and be provided with 1/2" or 3/4" threads for box mounting. Photocells shall be Model K4121C by Intermatic, or equal.
- B. Lighting Contactor and Astronomical Time Clock
  - 1. Furnish and install a lighting contactor with integral astronomical time clock to control lighting as indicated on the Drawings.
  - 2. Lighting contactors shall be Model ET2845C as manufactured by Intermatic or approved equal. Lighting contactors shall be heavy duty type and shall include four

(4) SPST contacts rated for 30A at 120-277VAC, minimum (per contact). The SPST contacts shall be capable of being operated in pairs for 2-pole SPDT operation. The four (4) integral contacts shall allow for direct control of up to four (4) lighting circuits as indicated on the Drawings. Lighting contactors shall include an integral electronic controller as specified herein. In addition, any auxiliary relays or other devices required for proper operation shall be included.

- 3. Integral programmable electronic astronomic controller shall be 365/7-day type, capable of permitting up to 48 ON and 48 OFF events. Controllers shall include selectable astronomic (dusk/dawn) settings for each day and each circuit to allow load switching at sunset and/or sunrise without a photo control device. Controllers shall provide a minimum ON or OFF time of 1 minute. Controllers shall operate on a 120 VAC, 60 Hz control power supply. The electronic controller shall be UL 916 Listed.

- C. In non-hazardous locations, lighting contactors shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

**PART 3 – EXECUTION**

**3.01 INSTALLATION**

- A. Lighting fixtures shall be located symmetrically with building lines as shown on the Drawings. The Contractor shall furnish and install the lighting fixtures to allow "convenient" access for maintenance. The Contractor shall install fixtures at mounting heights indicated on the Drawings or as instructed by the Engineer. In areas with exposed ducts and/or piping, installation of lighting fixtures shall be adapted to field conditions as determined by the Engineer. Where fixtures are shown in locations on the Drawings where maintenance would be difficult, the Contractor shall notify the Engineer for direction.
- B. The Contractor shall provide and install all inserts, conduit, structural supports as required, lamps, ballasts, poles, wiring, and any other items required for a complete system. Contractor shall properly adjust and test, to the satisfaction of the Engineer, the entire lighting system. The Contractor shall provide pigtails and flexible conduit connected to an outlet box where necessary or required resulting in a neat and complete installation.

- C. The Contractor shall protect all fixtures at all times from damage, dirt, dust, and the like. Upon completion of work, and after the building area is broom clean, all fixtures shall be made clean and free of dust and all other foreign matter both on visible surfaces, and on surfaces that affect the lighting performance of the fixture including diffusers, lenses, louvers, reflectors, and lamps.
- D. The Contractor shall furnish and install all pendant trapezes and pendant stem hangers with durable swivel or equivalent trapeze hanger permitting normal fixture motion and self-alignment. Fixture pendants shall be Appleton Type UNJ ball type flexible hanger at the fixture and supports from an Appleton JBLX junction box with JBLX hub cover, or equal. Pendant lengths shall be adequate and adjusted to provide uniformity of installation heights above the reference datum. Stems shall be one-piece, with matching canopies and fittings.
- E. All wiring/cables associated with lighting equipment shall be installed in conduits or other raceways as specified. Installing wiring/cables exposed is not acceptable, unless specifically shown otherwise on the Drawings.
- F. The Contractor shall furnish and install recessed fixtures with a separate junction box concealed and located as to be accessible when fixture is removed.
- G. The Contractor shall furnish and install all boxes for lighting fixtures such that the box is not the sole support of the fixture. The boxes shall be offset to allow maintenance such that access to wiring within the box can be attained without having to consider supporting (holding) the fixture.
- H. All lighting fixtures, when installed, shall be set true and be free of light leaks, warps, dents, and other irregularities. All hangers, cables, supports, channels, and brackets of all kinds for safely erecting this equipment in place, shall be furnished and erected in place by the Contractor.
- I. The Contractor shall support each fixture securely. The Contractor shall not secure fixtures to the work of other trades, unless specified or noted otherwise, and shall not support fixtures from plaster. The Contractor shall furnish and install all members and supports as required to fasten and suspend fixtures from the structure.
- J. In all mechanical equipment areas, the Contractor shall install lighting fixtures after all piping and equipment therein has been installed. Exact locations for such fixtures may be determined by the Engineer on the site during the course of the work.
- K. All fixtures that require physical adjustment shall be so adjusted in accordance with the directions of the Engineer. The Contractor shall also adjust angular direction of fixtures and/or lamps, as directed.
- L. No special tools shall be required for re-lamping of fixtures. All optical control surfaces such as lenses and reflectors shall be safely and securely attached to fixtures and shall be easily and quickly removed and replaced for cleaning without the use of special tools.

- M. Lighting contactors shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

### **3.02 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
  - 1. Certified Shop Tests
    - a. The lighting fixtures shall be given routine factory tests in accordance with the requirement of ANSI, NEMA and Underwriters Laboratories standards.
  - 2. Field Tests
    - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA Acceptance Testing Specifications, latest edition.

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**SECTION 31 00 01**  
**EARTHWORK**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all labor, equipment and materials required to complete all work associated with excavation, including off-site borrow excavation, dewatering, backfill, drainage layers beneath and around structures, foundation and backfill stone, filter fabric, embankments, stockpiling topsoil and any excess suitable material in designated areas, in place compaction of embankments, backfill and subgrades beneath foundations and roadways, excavation support, disposing from the site all unsuitable materials, providing erosion and sedimentation control grading, site grading and preparation of pavement and structure subgrade, and other related and incidental work as required to complete the work shown on the Drawings and specified herein.
- B. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Drawings or established by the Engineer.
- C. It is the intent of this Specification that the Contractor conduct the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized.
- D. All work under this Contract shall be done in conformance with and subject to the limitations of the latest editions of the Georgia Department of Transportation Standard Specifications and the Georgia Manual for Erosion and Sediment Control.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia Department of Transportation Standard Specifications, latest edition.
  - 2. American Society for Testing and Materials (ASTM):
    - a. ASTM C 127 – Test for Specific Gravity and Absorption of Coarse Aggregate.

- b. ASTM C 136 – Test for Sieve Analysis of Fine and Coarse Aggregates.
- c. ASTM D 422 – Particle Size Analysis of Soils.
- d. ASTM D 423 – Test for Liquid Limit of Soils.
- e. ASTM D 424 – Test for Plastic Limit and Plasticity Index of Soils.
- f. ASTM C 535 – Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
- g. ASTM D 698 – Standard Method of Test for the Moisture - Density Relations of Soils Using a 5.5 lb. (2.5 kg) Rammer and a 12-inch (305 mm) Drop.
- h. ASTM D1556 – Test for Density of Soil in Place by the Sand-Cone Method.
- i. ASTM D1557 – Test for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lbs. (4.5 kg) Rammer and 18-inch (457 mm) Drop.
- j. ASTM D2049 – Test Method for Relative Density of Cohesionless Soils.
- k. ASTM D2167 – Test for Density of Soil in Place by the Rubber-Balloon Method.
- l. ASTM D2216 – Test for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures.
- m. ASTM D2487 – Test for Classification of Soils for Engineering Purposes.
- n. ASTM D2922 – Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

#### **1.04 SUBSURFACE CONDITIONS**

- A. Information on subsurface conditions is referenced under Division 1, General Requirements.
- B. Attention is directed to the fact that there may be water pipes, storm drains and other utilities located in the area of proposed excavation. Perform all repairs to same in the event that excavation activities disrupt service.

#### **1.05 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, the Contractor shall submit the following:
  - 1. Name and location of all material suppliers.



2. Certificate of compliance with the standards specified above for each source of each material.
3. List of disposal sites for waste and unsuitable materials and all required permits for use of those sites.
4. Plans and cross sections of open cut excavations showing side slopes and limits of the excavation at grade.
5. Samples of synthetic filter fabric and reinforced plastic membrane with manufacturer's certificates or catalog cuts stating the mechanical and physical properties. Samples shall be at least one (1) foot wide and four (4) feet long taken across the roll with the warp direction appropriately marked.
6. Construction drawings and structural calculations for any types of excavation support required. Drawings and calculations shall be sealed by a currently registered Professional Engineer in the State of Georgia.
7. Monitoring plan and pre-construction condition inspection and documentation of all adjacent structures, utilities, and roadways near proposed installation of excavation support systems and near areas where dewatering is required to facilitate construction.
8. Dewatering procedures.

#### **1.06 PRODUCT HANDLING**

- A. Soil and rock material shall be excavated, transported, placed, and stored in a manner so as to prevent contamination, segregation and excessive wetting. Materials which have become contaminated or segregated will not be permitted in the performance of the work and shall be removed from the site.

#### **1.07 USE OF EXPLOSIVES**

- A. When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property. The Contractor shall be responsible for any and all damage or injury to persons or property resulting from the use of explosives. Use of explosives shall be in accordance with Section 31 23 16 – Excavation by Blasting.

### **PART 2 – PRODUCTS**

#### **2.01 SELECT FILL**

- A. Soils from the excavations meeting requirements stipulated herein with the exceptions of topsoil and organic material may be used as Select Fill for backfilling, constructing

embankments, reconstructing existing embankments, and as structural subgrade support.

- B. Select Fill used for embankment construction shall be soil, sand, or gravel classified per the Unified Soil Classification System (USCS) as SP, SM, SW, GP, GW with a maximum of 20 percent by weight fines passing the No. 200 sieve and a Plasticity Index (PI) between 7 and 20 for silty or clayey material and a Maximum PI of 6 for granular material.
- C. Granular Select Fill shall consist of sandy gravel or gravelly sand, free of organic material, environmental contaminants, snow, ice, frozen soil, or other unsuitable material, and be well-graded within the following limits:

<b>U.S. Standard Sieve Size</b>	<b>Percent Finer by Weight</b>
3 in.	100
No. 4	30-80
No. 40	10-50
No. 200	0-8

- D. Regardless of material used as Select Fill, materials shall be compacted at a moisture content satisfactory to the Engineer, which shall be approximately that required to produce the maximum density except that the moisture content shall not be more than 1% below nor more than 4% above the optimum moisture content for the particular material tested in accordance with the ASTM D698.
- E. Where excavated material does not meet requirements for Select Fill, Contractor shall furnish off-site borrow material meeting the specified requirements herein. Determination of whether the borrow material will be paid for as an extra cost will be made based on Article 4 of the General Conditions, as amended by the Supplementary Conditions.
- F. When the excavated material from required excavations is suitable for use as Select Fill, backfill, bedding, or embankments, but is replaced with off-site borrow material for the Contractor's convenience, the costs associated with such work and material shall be borne by the Contractor.
- G. Contractor shall stockpile on site in areas designated in the Contract Documents or as approved by the Owner to avoid hauling material offsite unless contaminated. No stockpiling of excavated material would be allowed within 50 feet or in a manner or location that would permit erosion and its subsequent sedimentation into storm drains, streams, ponds, wetlands or other natural areas.

- 1. Topsoil

- a. Topsoil shall be considered the surface layer of soil and sod, suitable for use in seeding and planting. It shall contain no mixture of refuse or any material toxic to plant growth.
2. Foundation Drainage Systems
  - a. The Contractor shall provide foundation drainage systems as indicated on the Drawings and specified herein. The materials and placement shall be as indicated under Section 33 41 13 – Foundation Drainage Systems.
3. Geotextiles
  - a. The Contractor shall provide geotextiles as indicated on the Drawings and specified herein. The materials and placement shall be as indicated under Section 31 05 19 – Geotextiles.

## **PART 3 – EXECUTION**

### **3.01 STRIPPING OF TOPSOIL**

- A. In all areas to be excavated, filled, paved, or graveled the topsoil shall be stripped to its full depth and shall be deposited in storage piles on the site, at locations designated by the Engineer, for subsequent reuse. Topsoil shall be kept separated from other excavated materials and shall be piled free of roots and other undesirable materials.

### **3.02 EXCAVATION**

- A. All material excavated, regardless of its nature or composition, shall be classified as UNCLASSIFIED EXCAVATION. Excavation shall include the removal of all soil, rock, weathered rock, rocks of all types, boulders, conduits, pipe, and all other obstacles encountered and shown to be removed within the limits of excavation shown on the Drawings or specified herein. The cost of excavation shall be included in the Lump Sum Bid Price and no additional payment will be made for the removal of obstacles encountered within the excavation limits shown on the Drawings and specified herein.
- B. Where blasting is necessary to perform the required excavations, blasting shall be performed as stipulated in Section 31 23 16 – Excavation by Blasting.
- C. All suitable material removed in the excavation shall be used as far as practicable in the formation of embankments, subgrades, and shoulders, and at such other places as may be indicated on the Drawings or indicated by the Engineer. No excavation shall be wasted except as may be permitted by the Engineer. Refer to the drawings for specific location and placement of suitable excavated materials in the formation of embankments, backfill, and structural and roadway foundations. THE ENGINEER AND/OR MATERIALS TESTING CONSULTANT WILL DESIGNATE MATERIALS THAT ARE UNSUITABLE. The Contractor shall furnish off-site disposal areas for the

unsuitable material. Where suitable materials containing excessive moisture are encountered above grade in cuts, the Contractor shall construct above grade ditch drains prior to the excavation of the cut material when in the opinion of the Engineer and/or materials testing consultant such measures are necessary to provide proper construction.

- D. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such excavation support, pumping and drainage as may be required. Excavation shall be made in accordance with the grades and details shown on the Drawings and as specified herein.
- E. Excavation slopes shall be flat enough to avoid slides that will cause disturbance of the subgrade or damage of adjacent areas. Excavation requirements and slopes shall be as indicated in the Drawings. The Contractor shall intercept and collect surface runoff both at the top and bottom of cut slopes. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded as shown on the Drawings or as may be indicated by the Engineer. Concurrent with the excavation of cuts the Contractor shall construct intercepting berm ditches or earth berms along and on top of the cut slopes at locations shown on the Drawings or designated by the Engineer. All slopes shall be finished to reasonably uniform surfaces acceptable for seeding and mulching operations. No rock or boulders shall be left in place which protrude more than 1 foot within the typical section cut slope lines, and all rock cuts shall be cleaned of loose and overhanging material. All protruding roots and other objectionable vegetation shall be removed from slopes. The Contractor shall be required to submit plans of open-cut excavation for review by the Engineer before approval is given to proceed.
- F. It is the intent of these Specifications that all structures shall bear on an aggregate base, crushed stone or screened gravel bedding placed to the thickness shown on the Drawings, specified in these Specifications, or not less than 6-inches. Bedding for process piping shall be as specified in Section 40 05 00 – Basic Mechanical Requirements, or as shown on the Drawings.
- G. The bottom of all excavations for structures and pipes shall be examined by the Engineer and/or materials testing consultant for bearing value and the presence of unsuitable material. If, in the opinion of the Engineer and/or materials testing consultant, additional excavation is required due to the low bearing value of the subgrade material, or if the in-place soils are soft, yielding, pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted select fill, and/or crushed stone or screened gravel as indicated by the Engineer. Payment for such additional work ordered by the Engineer shall be made as an extra by a Change Order in accordance with the General Conditions and Division 1. No payment will be made for subgrade disturbance caused by inadequate dewatering or improper construction methods.

- H. All cuts shall be brought to the grade and cross section shown on the Drawings, or established by the Engineer, prior to final inspection and acceptance by the Engineer.
- I. Slides and overbreaks which occur due to negligence, carelessness or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as indicated by the Engineer at no additional cost to the Owner. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed.
- J. Where the excavation exposes sludge, sludge contaminated soil or other odorous materials, the Contractor shall cover such material at the end of each workday with a minimum of 6-inches and a maximum of 24-inches of clean fill. The work shall be an odor abatement measure and the material shall be placed to the depth deemed satisfactory by the Engineer for this purpose.

### **3.03 EXCAVATION SUPPORT**

- A. The Contractor shall furnish, place, and maintain such excavation support which may be required to support sides of excavation or to protect structures, pipes, and utilities from possible damage and to provide safe working conditions. The Contractor shall be exclusively responsible for maintaining structure integrity without overstressing and damaging existing structures, pipes, and utilities resulting from the Contractor's desires to temporarily place, move, or remove loads on or adjacent to existing structures, pipes, and utilities. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the expense of the Contractor. The Contractor shall be responsible for the adequacy of all supports used and for all damage resulting from failure of support system or from placing, maintaining and removing it.
- B. Selection of and design of any proposed excavation support systems is exclusively the responsibility of the Contractor. Contractor shall submit drawings and calculations on proposed systems sealed by a Professional Engineer currently registered in the State of Georgia.
- C. The Contractor shall exercise caution in the installation and removal of supports to ensure no excessive or unusual loadings or vibrations are transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to installation or removal of excavation support system.
- D. Contractor shall monitor movement and vibration in the excavation support systems as well as movement and vibration at adjacent structures, utilities and roadways near excavation supports. Contractor shall submit a monitoring plan developed by the excavation support design engineer. All pre-construction condition assessment and

documentation of adjacent structures on-site and off-site shall be performed by the Contractor. If any sign of distress such as cracking or movement occurs in any adjacent structure, utility or roadway during installation of supports, subsequent excavation, service period of supports, subsequent backfill and construction, or removal of supports, Engineer shall be notified immediately. Contractor shall be exclusively responsible for repair of any damage to any roadway, structure, utility, pipes, etc. both on-site and off-site, as a result of his operations.

- E. All excavation supports shall be removed upon completion of the work except as indicated herein. The Engineer may permit supports to be left in place at the request and expense of the Contractor. The Engineer may order certain supports left permanently in place in addition to that required by the Contract. The cost of the materials so ordered left in place, less a reasonable amount for the eliminated expense of the removal work omitted, will be paid as an extra by a Change Order in accordance with the General Conditions and Division 1. Any excavation supports left in place shall be cut off at least two (2) feet below the finished ground surface or as directed by the Engineer.

### **3.04 PROTECTION OF SUBGRADE**

- A. To minimize the disturbance of bearing materials and provide a firm foundation, the Contractor shall comply with the following requirements:
  - 1. Use of heavy rubber-tired construction equipment shall not be permitted on the final subgrade unless it can be demonstrated that drawdown of groundwater throughout the entire area of the structure is at least 3 feet below the bottom of the excavation (subgrade). Even then, the use of such equipment shall be prohibited should subgrade disturbance result from concentrated wheel loads.
  - 2. Subgrade soils disturbed through the operations of the Contractor shall be excavated and replaced with compacted select fill or crushed stone at the Contractor's expense as indicated by the Engineer.
  - 3. The Contractor shall provide positive protection against penetration of frost into materials below the bearing level during work in winter months. This protection can consist of a temporary blanket of straw or salt hay covered with a plastic membrane or other acceptable means.

### **3.05 PROOFROLLING**

- A. The subgrade of all structures and all areas that will support pavements or select fill shall be proofrolled. After stripping of topsoil, excavation to subgrade and prior to placement of fills, the exposed subgrade shall be carefully inspected by probing and testing as needed. Any topsoil or other organic material still in place, frozen, wet, soft, or loose soil, and other undesirable materials shall be removed. The exposed subgrade shall be proofrolled with a heavily loaded tandem-wheeled dump truck to check for pockets of soft material hidden beneath a thin crust of better soil. Any unsuitable materials thus exposed shall be removed and replaced with an approved compacted material.

### **3.06 DEWATERING**

- A. The Contractor shall do all dewatering as required for the completion of the work. Procedures for dewatering proposed by the Contractor shall be submitted to the Engineer for review prior to any earthwork operations. All water removed by dewatering operations shall be disposed of in accordance with the Georgia Erosion and Sedimentation Act.
- B. The dewatering system shall be of sufficient size and capacity as required to control groundwater or seepage to permit proper excavation operations, embankment construction and reconstruction, subgrade preparation, and to allow concrete to be placed in a dry condition. The system shall include a sump system or other equipment, appurtenances and other related earthwork necessary for the required control of water. The Contractor shall drawdown groundwater to at least 3 feet below the bottom of excavations (subgrade) at all times in order to maintain a dry and undisturbed condition.
- C. The Contractor shall control, by acceptable means, all water regardless of source. Water shall be controlled, and its disposal provided for at each berm, structure, etc. The entire periphery of the excavation areas shall be ditched and diked to prevent water from entering the excavation. The Contractor shall be fully responsible for disposal of the water and shall provide all necessary means at no additional expense to the Owner. The Contractor shall be solely responsible for proper design, installation, proper operation, maintenance, and any failure of any component of the system.
- D. The Contractor shall be responsible for and shall repair without cost to the Owner, any damage to work in place and the excavation, including damage to the bottom due to heave and including removal of material and pumping out of the excavated area. The Contractor shall be responsible for damages to any other area or structure caused by his failure to maintain and operate the dewatering system proposed and installed by the Contractor.
- E. The Contractor shall take all the steps that he considers necessary to familiarize himself with the surface and subsurface site conditions, and shall obtain the data that is required to analyze the water and soil environment at the site and to assure that the materials used for the dewatering systems will not erode, deteriorate, or clog to the extent that the dewatering systems will not perform properly during the period of dewatering. Copies of logs of borings and laboratory test results are available to the Contractor. This data is furnished for information only, and it is expressly understood that the Owner and Engineer will not be held responsible for any interpretations or conclusions drawn therefrom by the Contractor.
- F. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of adjoining structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

### 3.07 EMBANKMENTS

1. The Contractor shall perform the construction of embankments in such a manner that cut and fill slopes will be completed to final slopes and grade in a continuous operation. The operation of removing excavation material from any cut and the placement of embankment in any fill shall be a continuous operation to completion unless otherwise permitted by the Engineer.
2. Surfaces upon which embankments are to be constructed shall be stripped of topsoil, organic material, rubbish and other extraneous materials. After stripping and prior to placing embankment material, the Contractor shall compact the top 12-inches of in place soil as specified under Paragraph 3.09, COMPACTION.
3. Any soft or unsuitable materials revealed before or during the in place compaction shall be removed as indicated by the Engineer and/or materials testing consultant and replaced with select fill.
4. Ground surfaces on which embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the embankment with the existing surface. The embankment soils shall be as specified under Part 2 - Products, and shall be deposited and spread in successive, uniform, approximately horizontal layers not exceeding 8-inches in compacted depth for the full width of the cross section and shall be kept approximately level by the use of effective spreading equipment. Hauling shall be distributed over the full width of the embankment, and in no case will deep ruts be allowed to form during the construction of the embankment. The embankment shall be properly drained at all times. Each layer of the embankment shall be thoroughly compacted to the density specified under Paragraph 3.09, COMPACTION.
5. The embankment or fill material in the layers shall be of the proper moisture content before rolling to obtain the prescribed compaction. Wetting or drying of the material and manipulation when necessary to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankment thus affected shall be delayed until the material has dried to the required moisture content. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken at frequent intervals. From these tests, corrections, adjustments, and modifications of methods, materials, and moisture content will be made to construct the embankment.
6. Where embankments are to be placed and compacted on hillsides, or when new embankment is to be compacted against embankments, or when embankment is built in part widths, the slopes that are steeper than 4:1 shall be loosened or plowed to a minimum depth of 6 inches or, if in the opinion of the Engineer, the nature of the ground is such that greater precautions should be taken to bind the



fill to the original ground then benches shall be cut in the existing ground as indicated by Engineer.

7. When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portions of the embankments and the other material which meets the requirements for select fill shall be incorporated into the formation of the embankments. Stones or fragmentary rock larger than 4-inches in their greatest dimension will not be allowed within the top 6-inches of the final grade. Stones, fragmentary rock, or boulders larger than 12-inches in their greatest dimension will not be allowed in any portions of embankments and shall be disposed of by the Contractor as indicated by the Engineer. When rock fragments or stone are used in embankments, the material shall be brought up in layers as specified or directed and every effort shall be exerted to fill the voids with finer material to form a dense, compact mass which meets the densities specified for embankment compaction.

### **3.08 BACKFILLING**

- A. All structures and pipes shall be backfilled with the type of materials shown on the Drawings and specified herein. Select fill shall be deposited in successive, uniform, approximately horizontal layers not exceeding 8-inches in compacted depth for the full width. Stones or fragmentary rock larger than 4-inches in their greatest dimension will not be allowed within the top 6-inches of the ground nor within 6 inches of pipes. No stone or fragmentary rock larger than 12-inches in their greatest dimension will be allowed for any portion of backfill. Compaction shall be in accordance with the requirements of Paragraph 3.09, COMPACTION.
- B. Where excavation support is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when supports are removed. If significant volumes of soil cannot be prevented from clinging to the extracted supports, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that supports will be installed in similar soil conditions or employ other appropriate means to prevent loss of support.

### **3.09 COMPACTION**

- A. The Contractor shall compact embankments, backfill, crushed stone, aggregate base, and in place subgrade in accordance with the requirements of this Section. The densities specified herein refer to percentages of maximum density as determined by the noted test methods. Compaction of materials on the project shall be in accordance with the following schedule:

	Density % Std. Proctor (D698)	Density % Mod. Proctor (D1557)	Max. Lift Thickness as Compacted Inches
Embankments Beneath Structures*	98	95	8
Other Embankments	95	92	8
Backfill Around Structures	95	92	8
Backfill in Pipe Trenches	95	92	8
Crushed Stone Beneath Structures	**	**	12
Select Sand	--	98	8
Aggregate Base Course (ABC) Beneath Pavements and Structures	--	98	8
Crushed Stone Backfill	**	**	12
Crushed Stone Pipe Bedding	**	**	12
In Place Subgrade Beneath Structures	98	95	Top 12-inches

\* Embankments beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope.

\*\* The aggregate shall be compacted to a degree acceptable to the Engineer by use of a vibratory compactor and/or crawler tractor.

- B. Field density tests will be made by the materials testing consultant to determine if the specified densities have been achieved, and these tests shall be the basis for accepting or rejecting the compaction. In-place density tests will be performed in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. The Engineer in conjunction with the materials testing consultant will be the judge as to which test method will be the most appropriate. Failure to achieve the specified densities shall require the Contractor to re-compact the material or remove it as required. The Contractor shall, if necessary, increase his compactive effort by increasing the number of passes, using heavier or more suitable compaction equipment, or by reducing the thickness of the layers. The Contractor shall adjust the moisture contents of the soils to bring them within the optimum range by drying them or adding water as required.
- C. Testing will be performed as frequently as deemed necessary by the Engineer and/or materials testing consultant. As a minimum, one in-place density test shall be performed for each 1000 cubic yards of embankment placed and 500 cubic yards of backfill placed or one test performed each day for either.

### 3.10 REMOVAL OF EXCESS AND UNSUITABLE MATERIALS

- A. The Contractor shall remove and dispose of off-site all unsuitable materials. Within thirty (30) consecutive days after Notice to Proceed, the Contractor shall submit to the Engineer for review all required permits and a list of disposal sites for the unsuitable materials. If the disposal site is located on private property, the submittal shall also include written permission from the owner of record.
- B. All unsuitable materials shall be disposed of in locations and under conditions that comply with federal, state and local laws and regulations.
- C. The Contractor shall obtain an off-site disposal area prior to beginning demolition or excavation operations.
- D. Any surplus excavated material not used for backfilling or embankment suitable for reuse shall be deposited on-site in the disposal area indicated on the Drawings or as directed by the Engineer. Approved disposal areas may also be used by the Contractor for spreading and drying any excavated material suitable as select fill that is too wet for use immediately after being excavated. The Contractor shall maintain the earth surfaces of the disposal area, both during the work and until the completion of all seeding and mulching or other erosion control measures specified, in a manner which will effectively control erosion and sedimentation. If necessary, the Contractor shall clear and grub the disposal site prior to any excavation work.
  - 1. Earth waste shall be shaped to contours which are comparable to and blend in with the adjacent topography where practical, but in no case will slopes steeper than 3 horizontal to 1 vertical be permitted.
  - 2. Seeding and mulching shall be performed over all the earth waste area. The work of seeding and mulching shall be performed in accordance with Section 32 90 00 – Final Grading and Landscaping.
  - 3. The Engineer shall have the authority to establish whatever additional requirements may be necessary to insure the satisfactory appearance of the completed work.
- E. When all excess and unsuitable material disposal operations are completed, the Contractor shall leave the disposal sites in a condition acceptable to the Owner and Owner(s) of the disposal site(s).

### **3.11 BORROW EXCAVATION**

- A. Description
  - 1. The work covered by this section consists of the excavation of approved material from borrow sources and the hauling and utilization of such material as required on the Drawings or directed by the Engineer. It shall also include the removing, stockpiling, and replacement of topsoil on the borrow source; the satisfactory disposition of material from the borrow source which is not suitable for use; and

the satisfactory restoration of the borrow source and haul roads to an acceptable condition upon completion of the work.

2. Borrow excavation shall not be used before all available suitable unclassified excavation has been used for backfill and incorporated into the embankments.

#### B. Coordination with Seeding Operations

1. The Contractor shall coordinate the work covered by this section with the construction of embankments so that the requirements of Section 31 00 01 – Earthwork are met.

#### C. Materials

1. All material shall meet the requirements of Division 2 shown below:
2. Borrow Material: Section 31 00 01 – Earthwork, Paragraph 2.01 – Select Fill

#### D. Construction Methods

##### 1. General

- a. The surface of the borrow area shall be thoroughly cleared and grubbed and cleaned of all unsuitable material including all organics, topsoil, etc., before beginning the excavation. Disposal of material resulting from clearing and grubbing shall be in accordance with Section 31 10 00 – Clearing, Grubbing, and Site Preparation.
- b. Each borrow operation shall not be allowed to accumulate exposed, erodible slope area in excess of 1 acre at any one given time without the Contractor's beginning permanent seeding and mulching of the borrow source or other erosion control measures as may be approved by the Engineer.
- c. The topsoil shall be removed and stockpiled at locations that will not interfere with the borrow operations and that meet the approval of the Engineer. Temporary erosion control measures shall be installed as may be necessary to prevent the erosion of the stockpile material. Once all borrow has been removed from the source or portion thereof, the stockpiled topsoil shall be spread uniformly over the source.
- d. Where it is necessary to haul borrow material over existing roads, the Contractor shall use all necessary precautions to prevent damage to the existing roads. The Contractor shall also conduct his hauling operations in such a manner as to not interfere with the normal flow of traffic and shall keep the traffic lanes free from spillage at all times.

##### 2. Owner Furnished Sources

- a. Where borrow sources are furnished by the Owner the location of such sources will be as designated on the Drawings or as directed by the Engineer.
- b. The Owner will furnish the necessary haul road right-of-way at locations designated by the Engineer. All haul roads required shall be built, maintained, and when directed by the Engineer, obliterated, at no cost to the Owner. Where the haul road is to be reclaimed for cultivation the Contractor shall plow or scarify the area to a minimum depth of 8 inches.
- c. The borrow sources shall be left in a neat and presentable condition after use. All slopes shall be smoothed, rounded, and constructed not steeper than 3:1. Where the source is to be reclaimed for cultivation the source shall be plowed or scarified to a minimum depth of 8 inches, disc harrowed, and terraces constructed. The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided.
- d. All sources shall be seeded and mulched in accordance with Section 32 90 00 – Final Grading and Landscaping.

### 3. Contractor Furnished Sources

- a. Prior to the approval of any off-site borrow source(s) developed for use on this project, the Contractor shall obtain certification from the State Historic Preservation Officer of the State Department of Cultural Resources certifying that the removal of the borrow material from the borrow source(s) will have no effect on any known district, site building, structure, or object that is included or eligible for inclusion in the National Register of Historic Places. A copy of this certification shall be furnished to the Engineer prior to performing any work on the proposed borrow source.
- b. The approval of borrow sources furnished by the Contractor shall be subject to the following conditions:
  - 1) The Contractor shall be responsible for acquiring the right to take the material and any rights of access that may be necessary; for locating and developing the source; and any clearing and grubbing and drainage ditches necessary.
    - a) Such right shall be in writing and shall include an agreement with the Owner that the borrow source may be dressed, shaped, seeded, mulched, and drained as required by these Specifications after all borrow has been removed.
  - 2) Except where borrow is to be obtained from a commercial source, the Contractor and the property owner shall jointly submit a borrow source development, use, and reclamation plan to the Engineer for his

approval prior to engaging in any land disturbing activity on the proposed source other than material sampling that may be necessary. The Contractor's plan shall address the following:

- a) Drainage: The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided. If drainage is not practical, and the source is to serve as a pond, the minimum average depth below the water table shall be 4 feet or the source graded so as to create wetlands as appropriate.
- b) Slopes: The source shall be dressed and shaped in a continuous manner to contours which are comparable to and blend in with the adjacent topography, but in no case will slopes steeper than 3:1 be permitted.
- c) Erosion Control: The plan shall address the temporary and permanent measures that the Contractor intends to employ during use of the source and as a part of the reclamation. The Contractor's plan shall provide for the use of staged permanent seeding and mulching on a continual basis while the source is in use and the immediate total reclamation of the source when no longer needed. If the source will require the disturbance of 1 acre or more of land, the Contractor shall be responsible for obtaining a Sediment and Erosion Control Permit from the Local Issuing Authority or Georgia EPD, whichever has jurisdiction.

#### 4. Maintenance

- a. During construction and until final acceptance the Contractor shall use any methods approved by the Engineer which are necessary to maintain the work covered by this section so that the work will not contribute to excessive soil erosion.

**END OF SECTION**

**SECTION 31 05 16**  
**AGGREGATE MATERIALS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish all labor, equipment and materials required to complete all work associated with the installation of aggregate material beneath foundations, as backfill and as roadway subgrades and other related and incidental work as required to complete the work shown on the Drawings and specified herein.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 42 00 – References
- B. Section 31 00 01 – Earthwork
- C. Section 31 25 00 – Erosion and Sedimentation Control
- D. Section 32 10 00 – Paving and Surfacing
- E. Section 32 90 00 – Final Grading and Landscaping

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. Georgia Department of Transportation (GDOT) Standard Specifications, Construction of Transportation Systems.
  - 2. ASTM C 127 – Test for Specific Gravity and Absorption of Coarse Aggregate.
  - 3. ASTM C 136 – Test for Sieve Analysis of Fine and Coarse Aggregates.
  - 4. ASTM C 535 – Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

**1.04 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
  - 1. Materials gradation and certification.

2. ASTM C127, ASTM C136, and ASTM C535 test results

## **PART 2 – PRODUCTS**

### **2.01 CRUSHED STONE, SCREENED GRAVEL AND GRADED AGGREGATE BASE (GAB)**

- A. Crushed stone or screened gravel shall meet the requirements of Aggregate Standard Size No. 57 or No. 67 as defined by GDOT Standard Specifications.
- B. GAB shall meet the requirements of GAB as defined by GDOT Standard Specifications.

### **2.02 SELECT SAND**

- A. Select sand shall meet the requirements of Section 801 Fine Aggregate of the GDOT Standard Specifications for materials and gradation.

## **PART 3 – EXECUTION**

### **3.01 CRUSHED STONE, SCREENED GRAVEL AND GRADED AGGREGATE BASE (GAB)**

- A. Contractor shall install crushed stone, screened gravel and GAB in accordance with the GDOT Standard Specifications and as shown on the Drawings and indicated in the Contract Documents.
  1. Unless otherwise stated herein or shown on the Drawings, all mat foundations (bottom slabs) for the proposed structures shall have a blanket of crushed stone or GAB 6-inches thick minimum placed directly beneath the proposed mat. The blanket shall extend a minimum of 12 inches beyond the extremities of the mat.
  2. For subgrade preparation at structures and structural fill, the foundation material shall be GAB where specifically specified on Drawings, otherwise, crushed stone or screened gravel shall be used.
  3. For ground under drains, pipe bedding, and drainage layers beneath structures the coarse aggregate shall meet the requirements of aggregate standard Size No. 57 or No. 67, as defined by GDOT Standard Specifications.

### **3.02 SELECT SAND**

- A. Contractor shall install select sand in accordance with the GDOT Standard Specifications and as shown on the Drawings and indicated in the Contract Documents.

**END OF SECTION**



**SECTION 31 05 19**  
**GEOTEXTILES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install all Geotextiles, including all necessary and incidental items, as detailed or required for the Contractor to complete the installation in accordance with the Drawings and these Specifications.
- B. For the location of each type of Geotextile see the Drawings.

**1.02 REFERENCES**

- A. AASHTO Standards
  - 1. AASHTO M 288-06 (2011) Geotextile Specification for Highway Applications

**1.03 SUBMITTALS**

- A. Prior to shipping to the site, the Contractor shall submit to the Engineer two copies of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each type of Geotextile. The Supplier shall also submit three Geotextile samples of each product, 1 yard square each, seamed and unseamed as appropriate, with the mill certificate for each Geotextile type supplied. The mill certificate or affidavit shall attest that the Geotextile meets the chemical, physical and manufacturing requirements stated in the specifications. The samples shall be labeled with the manufacturer's lot number, machine direction, date of sampling, project number, specifications, manufacturer and product name.
- B. The Engineer shall be furnished copies of the delivery tickets or other acceptable receipts as evidence for materials received that will be incorporated into construction.

**PART 2 – MATERIALS**

**2.01 MATERIALS**

- A. Filter Geotextile shall be a minimum 6-ounce per square yard (nominal) nonwoven needle punched synthetic fabric consisting of staple or continuous filament polyester or polypropylene manufactured in a manner accepted by the Engineer and the Owner. The Geotextiles shall be inert and unaffected by long-term exposure to chemicals or liquids with a pH range from 3 to 10. The Geotextiles shall have a minimum threshold water head of 0.25-inches in the "as received" condition.

1. Filter Geotextile shall have a Survivability Class of Class 1, 2 or 3 in accordance with AASHTO M288, unless otherwise specified herein.
- B. Cushion Geotextile shall be a minimum 16-ounce per square yard nonwoven needle punched synthetic fabric consisting of continuous filament or staple polyester or polypropylene manufactured in a manner accepted by the Engineer and the Owner. The Geotextiles shall be inert and unaffected by long-term exposure to chemicals or liquids with a pH range from 3 to 10.
1. Cushion Geotextile shall have a Survivability Class of Class 1 in accordance with AASHTO M288.
- C. Type I Separator Geotextile shall be a minimum 8-ounce per square yard (nominal) nonwoven needle punched synthetic fabric consisting of staple or continuous filament polyester or polypropylene manufactured in a manner accepted by the Engineer and the Owner. The Geotextiles shall be inert and unaffected by long term exposure to chemicals or liquids with a pH range from 3 to 10.
1. Type I Separator Geotextile shall have a Survivability Class of Class 1 or 2 in accordance with AASHTO M288, unless otherwise specified herein.
- D. Type II Separator Geotextile shall be a woven slit film or monofilament synthetic fabric consisting of polyester or polypropylene in a manner approved by the Engineer. Geotextile shall be treated to resist degradation due to exposure to ultraviolet light.
1. Type II Separator Geotextile shall have a Survivability Class of Class 1 in accordance with AASHTO M288, unless otherwise specified herein.
- E. All Geotextiles shall conform to the properties listed using the test methods listed in Table 1. The Contractor shall be responsible for timely submittals of all confirmation test data for Geotextiles.

## **PART 3 – EXECUTION**

### **3.01 SHIPPING, HANDLING AND STORAGE**

- A. During all periods of shipment and storage, all Geotextiles shall be protected from direct sunlight, temperature greater than 140°F water, mud, dirt, dust, and debris.
- B. To the extent possible, the Geotextile shall be maintained wrapped in heavy-duty protective covering until use. Geotextile delivered to the project site without protective covering shall be rejected. After the protective covering has been removed, the Geotextile shall not be left uncovered for longer than fourteen (14) days, under any circumstances.

- C. The Owner shall approve the shipping and delivery schedule prior to shipment. The Owner shall designate the on-site storage area for the Geotextiles. Unloading and storage of Geotextiles shall be the responsibility of the Contractor.
- D. Geotextiles that are damaged during shipping or storage shall be rejected and replaced at Contractor expense.

### **3.02 QUALITY ASSURANCE CONFORMANCE TESTING**

- A. At the option of the Engineer representative samples of Geotextiles shall be obtained and tested by the Engineer to assure that the material properties conform to these Specifications. Conformance testing shall be conducted by the Engineer and paid for by the Owner.
- B. Conformance testing shall be completed at a minimum frequency of one sample per 100,000 square feet of Geotextile delivered to the project site. Sampling and testing shall be as directed by the Engineer.
- C. Conformance testing of the Geotextiles shall include but not be limited to the following properties:
  - 1. Mass Per Unit Area (ASTM D5261)
  - 2. Grab Tensile Strength (ASTM D4632)
  - 3. Trapezoidal Tear (ASTM D4533)
  - 4. Puncture Resistance (ASTM D6241)
- D. The Engineer may add to, remove or revise the test methods used for determination of conformance properties to allow for use of improved methods.
- E. All Geotextile conformance test data shall meet or exceed requirements outlined in Table 1 of these Specifications for the particular category of Geotextile prior to installation. Any materials that do not conform to these requirements shall be retested or rejected at the direction of the Engineer.
- F. Each roll of Geotextile will be visually inspected by the Engineer or his representative. The Engineer reserves the right to sample and test at any time and reject, if necessary, any material based on visual inspection or verification tests.
- G. A Geotextile that is rejected shall be removed from the project site and replaced at the Contractor's expense. Sampling and conformance testing of the Geotextile supplied as replacement for rejected material shall be performed by the Engineer at Contractor's expense.

### 3.03 INSTALLATION

- A. Geotextiles shall be placed to the lines and grades shown on the Drawings. At the time of installation, the Geotextile shall be rejected by the Engineer if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.
- B. It is the intent of these Specifications that Geotextiles used to protect natural drainage media be placed the same day as the drainage media to prevent soil, sediment or windblown soils to make contact with the drainage media.
- C. The Geotextiles shall be placed smooth and free of excessive wrinkles. Geotextiles shall conform to and be in contact with the approved subgrade.
- D. When the Geotextiles are placed on slopes, the upslope fabric portion shall be lapped such that it is the upper or exposed Geotextile.
- E. Geotextiles shall be temporarily secured in a manner accepted by the Engineer prior to placement of overlying materials.
- F. In the absence of specific requirements shown on the Drawings, the following shall be used for overlaps of adjacent rolls of Geotextile:

Geotextile Type / Application	Overlap of Adjacent Rolls <sup>(1)</sup> (Inches)	Transverse End Overlap (Inches)
Filter Geotextile	6 min	12 min
Cushion Geotextile	12 min	12 min
Separator - Roadway Applications	12 min	24 min
Separator - Slope Protection	18 min	24 min
Separator Geotextile	12 min	18 min

(1) Overlaps may be reduced if adjacent panels are sewn or heat bonded where approved by the Engineer.

- G. Any Geotextile that is torn or punctured shall be repaired or replaced as directed by the Engineer by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 12-inches from any point of the rupture.
- H. Any Geotextile that is subjected to excessive sediment buildup on its surface during construction shall be replaced by the Contractor prior to placement of overlying material.

**Table 1: Minimum Required Geotextile Properties\***

<b>Geotextile Property</b>	<b>Filter Geotextile</b>	<b>Cushion Geotextile</b>	<b>Type I Separator Geotextile</b>	<b>Type II Separator Geotextile</b>
Geotextile Construction	Nonwoven Needle punched	Nonwoven Needle punched	Nonwoven Needle punched	Woven
Mass per Unit Area (Unit Weight), ASTM D5261 (oz/yd <sup>2</sup> )	5.6	15.7	7.8	N/A
Ultraviolet Resistance, (500 hrs.) ASTM D7238, Average % Strength Retention	70	70	70	70
Grab Tensile Strength (lbs.), ASTM D4632	120	340	160	315
Grab Tensile elongation (%) ASTM D4632	50	50	50	50
Trapezoid Tear Strength (lbs) ASTM D4533	50	155	60	120
Apparent Opening Size (AOS), (mm), ASTM D4751	0.212	N/A	0.212	0.425
Permittivity at 50 mm constant head (sec <sup>-1</sup> ), ASTM D4491	0.5	N/A	1.5	0.1
CBR Puncture Strength, ASTM D6241 (lb)	340	1100	410	900

\* MINIMUM AVERAGE ROLL VALUE (MARV)

**END OF SECTION**

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**SECTION 31 10 00**  
**CLEARING, GRUBBING, AND SITE PREPARATION**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Includes all labor, material, equipment and appliances required for the complete execution of any additions, modifications, or alterations to existing building(s) and new construction work as shown on the Drawings and specified herein.
  
- B. Principal items of work include:
  - 1. Notifying all authorities owning utility lines running to or on the property. Protecting and maintaining all utility lines to remain and capping those that are not required in accordance with instructions of the Utility Companies, and all other authorities having jurisdiction.
  - 2. Clearing the site within the Contract Limit Lines, including removal of grass, brush, shrubs, trees, loose debris and other encumbrances except for trees marked to remain.
  - 3. Boxing and protecting all trees, shrubs, lawns and the like within areas to be preserved. Relocating trees and shrubs, so indicated on the Drawings, to designated areas.
  - 4. Repairing all injury to trees, shrubs, and other plants caused by site preparation operations shall be repaired immediately. Work shall be done by qualified personnel in accordance with standard horticultural practice and as approved by the Engineer.
  - 5. Removing topsoil to its full depth from designated areas and stockpiling on site where directed by the Engineer for future use.
  - 6. Disposing from the site all debris resulting from work under this Section.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 31 00 01 – Earthwork

**1.03 STREET AND ROAD BLOCKAGE**

- A. Closing of streets and roads during progress of the work shall be in compliance with the requirements of the Owner and other authorities having jurisdiction. Access shall be provided to all facilities remaining in operation.

## **1.04 PROTECTION OF PERSONS AND PROPERTY**

- A. All work shall be performed in such a manner to protect all personnel, workmen, pedestrians and adjacent property and structures from possible injury and damage.
- B. All conduits, wires, cables and appurtenances above or below ground shall be protected from damage.
- C. Provide warning and barrier fence where shown on the Drawings and as specified herein.

## **PART 2 – EXECUTION**

### **2.01 CLEARING OF SITE**

- A. Before removal of topsoil, and start of excavation and grading operations, the areas within the clearing limits shall be cleared and grubbed.
- B. Clearing shall consist of cutting, removal, and satisfactory disposal of all trees, fallen timber, brush, bushes, rubbish, sanitary landfill material, fencing, and other perishable and objectionable material within the areas to be excavated or other designated areas. Prior to the start of construction, the Contractor shall survey the entire Contract site and shall prepare a plan which defines the areas to be cleared and grubbed, trees to be pruned, extent of tree pruning, and/or areas which are to be cleared but not grubbed. This plan shall be submitted to the Engineer for approval. Should it become necessary to remove a tree, bush, brush or other plants adjacent to the area to be excavated, the Contractor shall do so only after permission has been granted by the Engineer.
- C. Excavation resulting from the removal of trees, roots and the like shall be filled with suitable material, as approved by the Engineer, and thoroughly compacted per the requirements contained in Section 31 00 01 – Earthwork.
- D. Unless otherwise shown or specified, the Contractor shall clear and grub a strip at least 15-ft. wide along all permanent fence lines installed under this Contract.
- E. In temporary construction easement locations, only those trees and shrubs shall be removed which are in actual interference with excavation or grading work under this Contract, and removal shall be subject to approval by the Engineer. However, the Engineer reserves the right to order additional trees and shrubs removed at no additional cost to the Owner, if such, in his opinion, are too close to the work to be maintained or have become damaged due to the Contractor's operations.

### **2.02 STRIPPING AND STOCKPILING EXISTING TOPSOIL**

- A. Existing topsoil and sod on the site within areas designated on the Drawings shall be stripped to whatever depth it may occur and stored in locations directed by the Engineer.



- B. The topsoil shall be free of stones, roots, brush, rubbish, or other unsuitable materials before stockpiling the topsoil.
- C. Care shall be taken not to contaminate the stockpiled topsoil with any unsuitable materials.

**2.03 GRUBBING**

- A. Grubbing shall consist of the removal and disposal of all stumps, roots, logs, sticks and other perishable materials to a depth of at least 6-inches below ground surfaces.
- B. Large stumps located in areas to be excavated may be removed during grading operations, subject to the approval of the Engineer.

**2.04 DISPOSAL OF MATERIAL**

- A. All debris resulting from the clearing and grubbing work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed by the Engineer for reuse in this Project or removal by others.
- B. Burning of any debris resulting from the clearing and grubbing work will not be permitted at the site.

**2.05 WARNING AND BARRIER FENCE**

- A. The fence shall be made of a visible, lightweight, flexible, high strength polyethylene material. The fence shall be Guardian Visual Barrier as manufactured by TEMAX, or equal.
- B. Physical Properties

<b>Fence</b>	
Color	International Orange
Roll Size	4' x 100'
Roll weight	9 lbs.
Mesh opening	1-3/4" x 1-3/4"
<b>Posts</b>	
ASTM Designation:	ASTM 702
Length:	6 feet long (T-Type)
Weight:	1.25 #/Foot (min)
Area of Anchor Plate:	14 Sq. In.

- C. Drive posts 18 inches into ground every 8'. Wrap fence material around first terminal post allowing overlap of one material opening. Use metal tie wire or plastic tie wrap to fasten material to itself at top, middle and bottom. At final post, cut with utility knife or scissors at a point halfway across an opening. Wrap around and tie at final post in the same way as the first post.
- D. Use tie wire or tie wrap at intermediate posts and splices as well. Thread ties around a vertical member of the fence material and the post and bind tightly against the post. For the most secure fastening, tie at top, middle and bottom. Overlap splices a minimum of four fence openings, tie as above, fastening both edges of the fence material splice overlap.

**END OF SECTION**

**SECTION 31 25 00**

**EROSION AND SEDIMENTATION CONTROL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor is responsible for implementing best management practices to prevent and minimize erosion and resultant sedimentation in all cleared and grubbed areas during and after construction.
- B. This item covers the work necessary for the installation of structures and measures for the prevention and control of soil erosion.
- C. The Contractor shall furnish all material, labor, and equipment necessary for the proper installation, maintenance, inspection, monitoring, reporting, and removal (where applicable) of erosion prevention and control measures and to cause compliance with the General NPDES Permit for Storm Water Discharges Associated With Construction Activity For Stand Alone Construction Projects under this Section.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 33 00 – Submittal Procedures.
- B. Section 31 00 01 – Earthwork.
- C. Section 31 05 16 – Aggregate Materials.
- D. Section 32 90 00 – Final Grading and Landscaping.

**1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. The Contractor shall be familiar with the following referenced documents and keep them at the construction site at all times. These documents need to be complied with as applicable.
  - 1. General NPDES Permit for Storm Water Discharges Associated With Construction Activity For Stand Alone Construction Projects (the NPDES Permit).
  - 2. Georgia Soil and Water Conservation Commission (GSWCC) Manual for Erosion and Sediment Control in Georgia (the “Green Book”), 2016 update.
  - 3. Georgia Department of Transportation Standard Specifications Construction of Transportation Systems (GDOT Standard Specifications).
  - 4. National Stone Association, Aggregate Classification (the NSA Classification).
  - 5. Clayton County Soil Erosion and Sediment Control Ordinance.

6. Erosion, Sedimentation, and Pollution Control Plan (the Plan) as required by the NPDES Permit.

#### 1.04 DEFINITIONS

- A. Engineer: For the purpose of this Section, the term Engineer is synonymous with consulting engineer, licensed professional, designer, and consultant used in permits, laws, rules, regulations, ordinances, and other soil erosion and sediment control references. For the purposes of this item, the Engineer may at any time during the project provide direction. This direction shall be considered equivalent to direction from the Engineer.
- B. Contractor: For the purposes of this Section, the term Contractor is synonymous with General Contractor, Discharger, Operator, Primary Permittee, and Permittee (permit holder) as used in permits, laws, rules, regulations, ordinances, and other soil erosion and sediment control references.
- C. Qualified Personnel: For the purposes of this Section, the terms Qualified Personnel or Qualified Person mean a person who has successfully completed an erosion and sediment controls short course eligible for continuing education units, or an equivalent course approved by Environmental Protection Division of the Georgia Department of Natural Resources and the State Soil and Water Conservation Commission.
- D. Other Definitions: Definitions as listed in the NPDES Permit, Part I.B shall apply in this section.

#### 1.05 REGULATORY COMPLIANCE

- A. Land disturbance activities are not authorized to begin until after all required erosion and sediment control permits are obtained from the United States, the State of Georgia, and/or Clayton County. Contractor is the Co-Primary Permittee and Operator under the provisions of the NPDES Permit GAR 100001. As such, Contractor will be required to sign certain certifications as described in the NPDES Permit. Contractor shall comply with requirements specified in the Contract Documents or by the Engineer. Contractor shall also comply with all other laws, rules, regulations, ordinances, and requirements concerning soil erosion and sediment control established in the United States, the State of Georgia, and/or Clayton County. The following documents and the documents referenced therein define the regulatory requirements for this Section.
  1. NPDES Permit: The General National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction Activity For Stand Alone Construction Projects (GAR 100001) governs land disturbance or construction activities of one (1) acre or more. On applicable sites, Contractor is responsible for complying with terms and conditions of this permit.
  2. GSWCC Manual for Erosion and Sediment Control in Georgia: Contractor shall follow Practices and Standards of the latest edition of the GSWCC for Erosion and Sediment Control in Georgia.

3. SWP3: When a Storm Water Pollution Prevention Plan (SWP3) is provided in the Contract Documents, the Contractor shall follow the practices described in the SWP3.

## **1.06 SUBMITTALS**

- A. Contractor shall submit to the Engineer the proposed schedule for installation, maintenance, and removal of all temporary and permanent erosion and sediment control measures. The schedule shall reflect the requirements of Article 1.07 and must show the anticipated starting and completion date for all land development activities including:
  1. Installation of temporary and permanent sediment control structures.
  2. Storm water management facilities.
  3. Timber salvage operations.
  4. Clearing operations.
  5. Grubbing operations.
  6. Rough and finished grading.
  7. Building construction.
  8. Landscaping, including all seeding and sodding.
  9. Removal of temporary sediment control structures.
- B. Submit the following in accordance with Section 01 33 00 – Submittals:
  1. Product Data.
  2. Hydroseed mix and application rates for seed, lime, fertilizer, and wood cellulose fiber mulch.
  3. Certification of all materials.
  4. Composition and germination certification of test results for grass seed.
- C. In accordance with the procedures and requirements set forth in the General Conditions Division 1 and Section 01 33 00 - Submittal Procedures, the Contractor shall submit the following:
  1. Name and location of all material suppliers.
  2. Certificate of compliance with the standards specified above for each source of each material.
  3. List of offsite borrow sources and disposal sites for waste and unsuitable materials and evidence of all required Federal, State, and local permits for use of those sites.

## **1.07 SEQUENCE OF CONSTRUCTION OF TEMPORARY SEDIMENT CONTROL MEASURES**

- A. Install all erosion and sediment control structures specified herein and shown in the Contract Documents, or as directed by the Engineer, as the first item of work within a given drainage area. Construction and installation of all sediment control structures shall begin downgrade of the area to be disturbed and shall proceed upgrade. Contractor shall at all times maintain all soil erosion and sediment control structures and practices throughout construction and until permanent grass cover is established.
- B. Time: Land disturbance activities are not authorized to begin until after all required erosion and sediment control permits are obtained from the United States, the State of Georgia, and/or the City.

## **PART 2 – PRODUCTS**

### **2.01 SPECIFIC REQUIREMENTS**

- A. The requirements specified herein and shown on the Drawings are minimum requirements for the preventing or minimizing soil erosion and sediment transport. Contractor shall install and maintain soil erosion and sediment control measures in accordance with the following criteria. Requirements set forth in the latest edition of the GSWCC Manual for Erosion and Sediment Control in Georgia shall govern in case of conflicting information, unless clearly identified as a deviation from the Manual.

### **2.02 TEMPORARY INTERCEPTOR, DIVERSION, AND PERIMETER DIKES**

- A. Install interceptor, diversion, and perimeter dikes to intercept and prevent storm water runoff from entering disturbed areas from any other upgrade area regardless of whether area is on-site or off-site. Dikes must divert runoff to a drainage ditch, sediment basin, or temporary or permanent channel. Dikes shall remain in place until the disturbed area is permanently stabilized. Construct dikes of earth fill free from all perishable matter and refuse, such as scrap forms, wire, brush, rocks larger than 6 inches, or any foreign materials. Ashes, large stones, muck, or other soft materials shall not be used. Compact all dikes using construction equipment. Dikes shall be stabilized immediately after construction with temporary seeding to prevent sediment transport to downstream areas.

### **2.03 TEMPORARY INTERCEPTOR, DIVERSION, AND PERIMETER DITCHES**

- A. Install temporary ditches where shown on the Drawings or as directed by the Engineer. In general, temporary ditches shall be installed parallel and contiguous to and upgrade of temporary dikes. Construct ditches to the lines and cross section shown on the drawings, provided that ditches have a minimum depth of 1 foot and side slopes have a slope of 2H:1V or flatter. Ditches shall be free of bank projections, trees, brush, stumps, or other objectionable materials or irregularities that will impede normal flows. Downstream outlets of temporary ditches shall be constructed and stabilized prior to construction of the ditch. The outlet must discharge in such a manner as to not cause an erosion problem.

## 2.04 TEMPORARY SEDIMENT BARRIERS (SILT FENCE)

- A. Install silt fence where shown on the Drawings or as directed by the Engineer.
- B. Material Specifications: Filter fabric must meet the requirements set forth in Section 171 – Silt Fence of the GDOT Standard Specifications. Contractor shall submit to Engineer copies of delivery invoices, certifications, or other documentation that the filter fabric complies with these specifications if requested by the Engineer.
- C. Installation: In general, silt fencing shall be installed on the downgrade side of all areas to be disturbed as well as the perimeter of the project site (Engineer may authorize an exception for a perimeter which is upgrade from all land disturbing activity). All posts used to install silt fence shall comply with the specifications in the latest edition of the GSWCC Manual for Erosion and Sediment Control in Georgia. Posts must be placed at least 18 inches in the ground and cannot be more than 6 feet apart from one another. Fence fabric must be inserted below ground and fence fabric must be fastened to posts according to the specifications in the Manual. Contractor shall install either Type A, Type B, or Type C silt fence, as shown in detail drawings, when indicated on the plans or when directed by the Engineer.
- D. Maintenance: In accordance with Article 3.01, all silt fencing shall be inspected and maintenance performed, if needed, within 24 hours of inspection and once every 7 calendar days and within 24 hours of a rainfall event that had precipitation of 1/2 inch or greater. All silt fencing materials, including fabric, post, and fasteners must be replaced 6 months after installation. At the earlier of (1) every 14 calendar days, or (2) when sediment reaches a depth of 1/3 the installed fence height, all soil, silt, sediment, and other material captured by the silt fence should be removed and returned upgrade on the construction site. The silt fence shall be maintained such that it minimizes sediment transport as designed.

## 2.05 TEMPORARY SEDIMENT BARRIERS (HAY BALES)

- A. Install bales of hay where shown on the Drawings or as directed by the Engineer.
- B. Material Specifications: Hay bales shall be wire or nylon bound and of rectangular shape.
- C. Installation: Place bales in a row with ends tightly abutting the adjacent bales. Corner abutment is not acceptable. Embed bales in the soil a minimum of 4 inches below grade. Build up backfilled soil a minimum of 4 inches above grade on the uphill side of the barrier and conform to grade on the downhill side of the barrier. Anchor each bale in place with 1 by 2 inch wood stakes or No. 3 reinforcing bars. The first stakes shall be driven toward the previously laid bale to force the bales together. Stakes shall be 24 inches long and shall reach a minimum of 6 inches into the ground.
- D. Maintenance: In accordance with Article 3.01, all hay bales shall be inspected and maintenance performed, if needed, within 24 hours of inspection once every 7 calendar days and within 24 hours of a rainfall event that has precipitation of 1/2 inch or greater. Hay bales must be replaced 1 month after installation. At the earlier of (1) every 14 calendar days or (2) when sediment and other material captured by the hay bales reaches 1/3 the height of the original bales such sediment should be removed and returned upgrade on the construction site. The hay bales shall be maintained such that they minimize sediment

transport as designed.

## 2.06 STONE FILTERS

- A. Install stone filter where shown on the Drawings or as directed by the Engineer.
- B. Material Specifications: Filter fabric must meet the requirements set forth in Section 171 – Silt Fence, of the GDOT Standard Specifications. Stone shall be No. 57 stone as defined by GDOT Standard Specifications. Contractor shall submit to Engineer copies of delivery invoices, certifications, or other documentation that the filter fabric, stone, and hardware cloth complies with these specifications if requested by the Engineer.
- C. Installation: In general, stone filters shall be installed at the low point of all silt fence as the perimeter of the project site (Engineer may authorize an exception for a perimeter which is upgrade from all land disturbing activity). All posts used to install silt fence shall comply with the specifications in the latest edition of the GSWCC Manual for Erosion and Sediment Control in Georgia. Posts must be placed at least 18 inches in the ground and cannot be more than 3 feet apart from one another. Fence fabric must be inserted below ground, and fence fabric and cloth hardware must be fastened to posts according to the specifications in the Manual. Contractor shall install fence as shown in detail drawings, when indicated on the plans, or when directed by the Engineer. Minimum length of stone filter shall be 10 feet.
- D. Maintenance: In accordance with Article 3.01, all stone filters shall be inspected and maintenance performed, if needed, within 24 hours of inspection and once every 7 calendar days and within 24 hours of a rainfall event that had precipitation of 1/2 inch or greater. All materials, including filter fabric, stone and cloth hardware, post, and fasteners must be replaced 6 months after installation. At the earlier of (1) every 14 calendar days, or (2) when sediment reaches a depth of 1/3 the installed height, all soil, silt, sediment, and other materials captured by the stone filter should be removed and returned upgrade on the construction site. The stone filter shall be maintained such that it minimizes sediment transport as designed. Hardware cloth between filter fabric and No. 57 stone shall be 1/2-inch mesh. Stone shall be No. 57 stone as defined by GDOT Standard Specifications.

## 2.07 CONSTRUCTION EXITS

- A. Locate construction exits as shown on the Drawings or as directed by the Engineer.
- B. Material Specifications: A geotextile underliner, conforming to Section 881.2.05 – Plastic Filter Fabric, GDOT Standard Specifications, shall be used in all instances to stabilize and support the pad aggregate. Aggregate size will conform to the National Stone Association's (NSA) R-2 classification 1-1/2-inch to 3-1/2-inch stone.
- C. Installation: Construction exits should be located at all points where traffic will be leaving the construction site to a public or private right of way, street, alley, or parking area. All construction exits must be fully installed prior to the commencement of timber salvage, clearing, grubbing, grading, or construction operations.
- D. Maintenance: In accordance with Article 3.01, all construction exits shall be inspected and maintenance performed, if needed, within 24 hours of inspection once every 7 calendar



days and within 24 hours of rainfall a event that has precipitation of 1/2 inch or greater. At the earlier of (1) 30 calendar days since construction exit was installed or last maintained, or (2) geotextile underliner is visible or if construction exit does not conform to specifications established in this section, construction exit pad shall be top dressed with NSA's R-2 (1-1/2-inch to 3-1/2-inch stone) such that underliner is no longer visible and exit pad conforms to specifications.

## **2.08 CHECK DAMS**

- A. Install check dams as shown on the Drawings or as directed by the Engineer.
- B. Installation: Install check dams in all ditches, channels, or swales draining disturbed areas of one (1) acre or greater and which are not installed with permanent, non-erodible lining or a vegetative cover as specified in Article 2.11. The specifications for the design criteria, materials, installation, and maintenance of check dams are dependent on the upslope drainage area and are described below. A check dam shall not drain a disturbed area greater than ten (10) acres.
  - 1. Check Dam for Ditches Draining up to 2 Acres: Hay bales may be used if installation conforms to the specifications established in Article 2.05.
  - 2. Check Dam for Ditches Draining Up to 5 Acres: Install stone check dams in ditches draining upgrade areas greater than 2 acres but less than 5 acres. Construct check dam with graded size 5- to 10-inch stone. Hand placement may be required to insure complete coverage of the entire width of ditch.
  - 3. Check Dam for Ditches Draining Up to 5 to 10 Acres: Check dams for use with drainage areas between 5 and 10 acres must serve as a sediment filtering device in addition to reducing the velocity of storm water runoff. Construct check dam with graded size 5- to 10-inch stone. Check dam shall not substantially impound water. Hand placement may be required to ensure complete width and depth of ditch.
- C. Maintenance: In accordance with the section titled Article 3.01, all check dams shall be inspected and maintenance performed, if needed, within 24 hours of inspection once every 7 calendar days and within 24 hours of a rainfall event that has precipitation of 1/2 inch or greater. Dress dams with appropriate sized stone or additional hay bales as necessary to maintain check dams in accordance with these specifications. At the earlier of (1) every 14 calendar days, or (2) when sediment reaches a depth of 1/3 the original check dam height, all soil, silt, sediment, and other material captured by the dam should be removed and returned upgrade on the construction site.

## **2.09 INLET SEDIMENT TRAP**

- A. Install inlet sediment traps where shown on the Drawings, as directed by the Engineer, and all around storm drain drop inlets that receive runoff from disturbed areas.
- B. Material Specifications: Filter fabric used on constructing inlet sediment traps shall conform to the specifications established in Article 2.06. For gravel drop inlet filters, stone shall conform to NSA's R-3 specification (3- to 6-inch stone). Baffle box inlet filters shall be constructed of 2-inch x 4-inch posts and 2-inch x 4-inch boards.

- C. Installation: Install in accordance with Chapter 6 of the latest edition of the GSWCC Manual for Erosion and Sediment Control in Georgia. Excavation may only be used in combination with a filtering device such as stone or silt fence. All sediment traps should provide a minimum of 1.5 feet of sediment storage. Sediment traps must be self-draining.
- D. Maintenance: In accordance with Article 3.01, all inlet sediment traps shall be inspected and maintenance performed, if needed, within 24 hours of inspection once every 7 calendar days and within 24 hours of a rainfall event that has precipitation of 1/2 inch or greater. Clean and repair traps such that traps meet the specifications of this section and minimize sediment transport. Remove sediment as necessary to provide adequate storage volume for subsequent rains.

## **2.10 TEMPORARY SEDIMENT BASINS AND INLETS**

- A. Install temporary sediment basins and inlets where shown on the Drawings or as directed by the Engineer.
- B. Material Specifications: Concrete used in constructing sediment basins shall be ready mixed, conforming to ASTM C 94, Alternate 2. Compressive strength shall be not less than 2,500 psi at 28 days. Maximum size of aggregate shall be 1-1/2-inch. Slump shall be between 2 and 4 inches. Field strength shall be assumed as equal to 85 percent of the strength of laboratory-cured cylinders. Forms used in constructing sediment basin shall have exposed surfaces of plywood; others shall be steel, matched boards, plywood, or other acceptable material. Form all vertical surfaces. Provide fillets on reentrant angles. Trench walls, large rock, or earth will not be acceptable form material. Reinforcing steel shall conform to ASTM A 615, Grade 40, deformed bars. At the option of the Contractor, approved precast units may be substituted for cast-in-place units. Precast units shall conform to ASTM C 478. Submit details of proposed units to the Engineer for review. Concrete risers for extension shall be a maximum of 6 inches high and of the same quality as the sections. Risers shall be reviewed by Engineer before installation. Mortar shall be standard premixed mortar conforming to ASTM C 387, Type S, or proportion 1 part Portland cement to 2 parts clean, well-graded sand which will pass a 1/8-inch screen. Admixtures may be used not exceeding the following percentages of weight of cement: Hydrated lime, 10 percent; diatomaceous earth or other inert materials, 5 percent. Consistency of mortar shall be such that it will readily adhere to the concrete. Cast iron frames and gratings for catch basins and storm drain inlets shall be designed for AASHTO H-20 truck loading and shall be bike-proof vetriculine grates. Bearing surfaces shall be clean and shall provide uniform contact. Castings shall be tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts and all defects, and shall conform to ASTM A 48, Class 30.
- C. Construction: Excavation of basin and backfill of any adjoining pipe trenches shall be as specified in Section 31 00 01 – Earthwork. Construct forms to the dimensions and elevations required. Forms shall be tight and well braced. Chamfer corners of forms. Prior to placing the concrete, remove all water and debris from the forms. Moisten forms just prior to placing the concrete. Handle concrete from the transporting vehicle to the forms in a continuous manner as rapidly as practical without segregation or loss of ingredients. Immediately after placing, compact concrete with a mechanical vibrator. Limit the duration of vibration to the time necessary to produce satisfactory consolidation without causing segregation. Screed the top surface of exposed slabs and walls. When the initial water has been absorbed, float the surfaces with a wood float and lightly trowel with a steel

trowel to a smooth finish free from marks or irregularities. Finish exposed edges with a steel edging tool. Remove forms and patch any defects in the concrete with mortar mixed in the same proportions as the original concrete mix. Cure concrete by preventing the loss of moisture for a period of 7 days. Accomplish with a membrane-forming curing compound. Apply the curing compound immediately after removal of forms or finishing of the slabs. Protect concrete from damage during the 7-day curing period. If precast unit is used and material in bottom of trench is unsuitable for supporting unit, excavate and backfill to required grade with 3-inch minus, clean pit-run material. Set units to grade at locations shown. Set frames and grates at elevations indicated on Drawings. Frames may be cast in, or shall be set in mortar.

- D. Maintenance: In accordance with Article 3.01, temporary sediment basins and inlets shall be inspected and maintenance performed, if needed, within 24 hours of inspection once every seven (7) calendar days and within 24 hours of a rainfall event that has precipitation of 1/2 inch or greater. Clean and repair basins and inlets such that they meet the specifications of Article 2.09 and minimize sediment transport. Remove sediment as necessary to provide adequate storage volume for subsequent rains.

## 2.11 TEMPORARY SOIL EROSION STABILIZATION (VEGETATIVE)

- A. This section covers work necessary for temporary stabilization of soil to prevent erosion following clearing, grubbing, grading, or other construction, except wetlands. The Engineer may modify the use, location, and quantity of the areas requiring stabilization as considered being in the best interest of the Owner. Temporary stabilization within a buffer zone of Water of the United States shall meet the requirements of Article 1.08.
- B. General Criteria: The stabilization measures specified herein shall be initiated on all disturbed areas including dikes and ditches within 24 hours of completion to minimize erosion and soil transport, provided however, that stabilization measures specified herein do not have to be initiated in the event that construction activities will resume on that portion of the site within fourteen (14) days from the date activities temporarily ceased. For cleared areas which may not receive permanent vegetative or other stabilization measure for six (6) months or less AND a suitable growing season is not available for seedings to establish an erosion retardant cover, mulch may be applied according to the specifications below.
- C. Material Specifications: Seed shall be clean, delivered in original unopened packages, and bearing an analysis of contents. Seed shall be guaranteed 95 percent pure with minimum germination rate of 85 percent. Seed mix shall be as shown in the Grassing Schedule, which is included in the Erosion, Sedimentation, and Pollution Control Plan. Alternative seed mixes may be approved by the Engineer. Fertilizer shall be commercial, chemical type, uniform in composition, free-flowing, conforming to state and federal laws, and suitable for application with equipment designed for that purpose. Fertilizer rates shall be as shown in the Grassing Schedule, which is included in the Erosion, Sedimentation, and Pollution Control Plan. Straw mulch shall be threshed straw of oats, wheat, or rye, free from obnoxious weed seeds or obnoxious weeds, or shall be clean hay. Average stalk length shall be 6 inches. Wood waste, asphaltic emulsion, or erosion control matting such as jute, excelsior, are appropriate for temporary stabilization. Asphaltic emulsion shall be CSS-1 as manufactured by Chevron Asphalt Company.

1. The Contractor shall submit to the Engineer certificates of inspection of seed by

state or federal authorities and copies of delivery invoices or other documentation of quantities of mulch and fertilizer.

2. The Contractor shall give at least 3 days notice to the Engineer of the time and place of the planting of grass.
  3. The Contractor shall keep the Engineer advised of his schedule of operations.
- D. Application (temporary seeding): Planting and seeding shall be performed in accordance with the following requirements:
3. Soil Preparation: Prior to seeding operations, and after surface has been shaped, graded, and compacted, scarify surface to a minimum depth of 1 inch.
  4. Seeding: All seedbeds shall be a minimum depth of 1 inch. Seedbeds shall be reviewed by the Engineer, prior to seeding. After soil has been scarified, apply required seed mix, uniformly with a hydro-seeder. Hydroseeding shall be as specified in Section 32 90 00 – Final Grading and Landscaping.
  5. The required fertilizer mix shall be uniformly applied at the time of seeding. Fertilizer shall not be applied to a land area with a buffer zone of a Water of the United States.
  6. Upon completion of the seeding operations, apply straw mulch to a reasonably uniform thickness of 1-1/2 inches to 2-1/2 inches in depth. Mulch shall be loose enough to permit penetration of sunlight and air circulation, but dense enough to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil. Retain straw in place by applying asphaltic emulsion at a rate of 100 gallons per acre or mechanically tack the mulch into the soil to approximately 3 inches. Equipment used for tacking shall be specially designed for this use. Mulch shall be paid for separately.
- E. Application of Mulch only: For areas to receive mulch only, apply at the following rates, to the following depths, and according to the following specifications:
1. Dry Straw or Hay: Spread at a rate of two and one half (2-1/2) tons per acre. Apply to a depth of 6 to 10 inches. Apply uniformly and anchor as necessary.
  2. Wood Waste: Spread at a rate of 6 to 9 tons per acre. Apply to a depth of 2 to 3 inches. Apply wood waste only on slopes that are 3:1 or flatter. Anchoring is not necessary.
  3. Jute Matting or Excelsior Netting: Apply in accordance with manufacturer's recommendations.
  4. Asphaltic Emulsion: Apply at a rate of 1,200 gallons per acre. Apply uniformly.
- F. Maintenance: In accordance with Article 3.01, all stabilized areas shall be inspected and maintenance performed, if needed, within 24 hours of inspection once every 7 calendar days and within 24 hours of a rainfall event that has precipitation of 1/2 inch or greater. Apply additional stabilization materials as needed.

- G. Polyacrylamide Stabilization: This section covers the use of the chemical anionic polyacrylamide to settle out silt and suspend solids from surface water and ground water prior to discharge. Application of polyacrylamide shall utilize a method and amount as recommended by the manufacturer and approved by the Engineer. Anionic polyacrylamide may be applied to disturbed areas in either Powder or Liquid/Emulsion form as described herein.
1. Material Specifications: Anionic polyacrylamide shall be water soluble and non-toxic. All anionic polyacrylamide products, whether in Powder or Liquid/Emulsion form, shall meet the USEPA Grade 2 classification, "Generally Regarded as Safe (GRAS)." The Contractor shall submit Material Safety Data Sheets (MSDS) to the Engineer for approval of the anionic polyacrylamide. Handling and application of the product shall adhere to the MSDS requirements and recommendations.
  2. Liquid/Emulsion form of anionic polyacrylamide shall be Applied Polymer Systems, Series 600, or equal. Powder form of anionic polyacrylamide shall be Applied Polymer Systems, Series 700, or equal. Specific polymer type used shall be as per manufacturer's recommendation for Cobb County soil classifications.
  3. Application: Liquid/Emulsion form of anionic polyacrylamide shall be applied to disturbed areas at a rate of 0.5 gallons of emulsion to 1,000 gallons of water. Powder form of anionic polyacrylamide shall be applied at a rate of 4 pounds per acre of disturbed area.
  4. Maintenance: Apply additional anionic Polyacrylamide as authorized or directed by the Engineer.

## **2.12 STRAW WITH NET TEMPORARY ROLLED EROSION CONTROL MAT (RECM)**

- A. The Contractor shall place straw with net temporary channel and slope RECM as shown on the Drawings. The mat shall consist of clean wheat straw from agricultural crops made into a knitted straw mat that is machine assembled. The straw shall be evenly distributed throughout the mat. The mat shall be covered with a photodegradable synthetic mesh attached to the straw with degradable thread.
- B. The Contractor shall place the straw with net temporary channel and slope RECM where directed immediately after the channel or slope has been properly graded and prepared, fertilized, and seeded. If the mat is of single net construction, the netting shall be on top with the straw in contact with the soil.
- C. The Contractor will immediately repair or replaced any section of straw with net temporary channel and slope RECM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.
- D. Straw with net RECM shall be North American Green S150, American Excelsior Co. Curlex I, Contech SFB1, or equal with a minimum bare soil shear stress value of 1.5 lb/ft<sup>2</sup>.

## **2.13 CURLED WOOD OR COCONUT FIBER ROLLED EROSION CONTROL MAT (RECM)**

- A. The Contractor shall place curled wood or coconut fiber channel and slope RECM in channels or on slopes as shown on the Drawings. The mat shall consist of machine-produced mat of curled wood excelsior or coconut fiber with a majority of the fibers 6 inches or longer with consistent thickness and the fibers evenly distributed over the entire area of the mat. The top of the mat shall be covered with a biodegradable synthetic mesh. The mesh shall be attached to the curled wood excelsior or coconut fiber with photodegradable synthetic yarn.
- B. The Contractor shall place the curled wood or coconut fiber channel and slope RECM where directed immediately after the channel or slope has been properly graded and prepared, fertilized, and seeded. If the mat is of single net construction, the mesh shall be on top with the fibers in contact with the soil.
- C. The Contractor will immediately repair or replace any section of curled wood or coconut fiber RECM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.
- D. Curled wood or coconut fiber RECM shall be American Excelsior Curlex II, North American Green C125, Contech EFB4, or equal matting with a minimum bare soil shear stress value of 2.0 lb/ft<sup>2</sup>.

## **2.14 SYNTHETIC TURF REINFORCEMENT MAT (TRM)**

- A. The Contractor shall place synthetic channel and slope TRM in channel or on slopes as shown on the Drawings. The mat shall consist of entangled nylon, polypropylene, or polyester monofilaments mechanically joined at their intersections forming a three dimensional structure. The mat shall be crush-resistant, pliable, water-permeable, and highly resistant to chemical and environmental degradation.
- B. The Contractor shall place the synthetic TRM where directed immediately after the channel or slope has been properly graded and prepared.
- C. After the TRM has been placed, the area shall be properly fertilized and seeded as specified allowing the fertilizer and seeds to drop through the net.
- D. The Contractor will immediately repair or replace any section of TRM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.
- E. Synthetic TRM shall be Enkamat 7020 as manufactured by Colbond Geosynthetics, Synthetic Industries Landlock Erosion Mat TRM 1060, Miramat TM8 as manufactured by TC Mirafi, or equal matting with a minimum long-term vegetated shear stress value of 5.0 lb/ft<sup>2</sup>.

## **2.15 TEMPORARY SLOPE DRAINS**

- A. Temporary slope drains shall be constructed as shown on the Drawings and as specified herein. The temporary slope drains shall be constructed and maintained in accordance with Article 3 of this Section to the satisfaction of the Engineer until the site has been

stabilized. The cost of the temporary slope drains shall include the piping, earthwork, stone for erosion control, and all maintenance activities required.

## **PART 3 -- EXECUTION**

### **3.01 INSPECTIONS AND MAINTENANCE**

- A. The Contractor shall designate a Qualified Person to perform inspections required by this Section. The following areas are to be inspected and maintenance performed, if needed, at least once every 7 calendar days and within 24 hours of a rainfall event that has a precipitation of 1/2 inch or greater. Immediate action will be taken to correct deficiencies to BMP's (Best Management Practices). The Owner reserves the right to stop all construction activities not related to maintaining BMP's until such deficiencies are repaired.
1. Disturbed areas of the construction site that have not undergone final stabilization.
  2. Erosion and sediment control structures.
  3. All locations where vehicles enter or exit the site.
  4. Material storage and construction laydown areas that are exposed to precipitation and have not been finally stabilized.
- B. In areas that have been finally stabilized, inspections and, if necessary, maintenance by Contractor will occur at least once per month for the duration of the contract or project, whichever is longer.
- C. During inspections the following will be observed and appropriate maintenance procedures taken:
1. The conformance to specifications and current condition of all erosion and sediment control structures.
  2. The effectiveness and operational success of all erosion and sediment control Measures.
  3. The presence of sediments or other pollutants in storm water runoff at all runoff discharge points.
  4. If reasonably accessible, the presence of sediments or other pollutants in receiving Waters.
  5. Evidence of off-site tracking at all locations where vehicles enter or exit the site.
- D. The Contractor shall be responsible for preparation of the inspection report as required by the NPDES Permit GAR 100001. Completed inspection reports shall be kept on-site with the Contract Documents and submitted to the Engineer on a monthly basis. The Contractor will repair deficiencies within 24 hours of inspection.

### **3.02 MONITORING AND REPORTING**

- A. Monitoring: The Contractor shall be responsible for the implementation of the monitoring program defined in the Erosion, Sedimentation, and Pollution Control Plan (the Plan) as required by the NPDES Permit. The implementation must comply with EPD guidelines as set forth in NPDES Permit No. GAR 100001, most recent version.
- B. Reporting: The Contractor shall prepare and submit a summary of the monitoring results to the Engineer, the Designer, and the EPD as required in the NPDES Permit GAR 100001 (Current Address: Mountain District – Mountain District - Atlanta Office, Georgia Environmental Protection Division, 4244 International Parkway, Atlanta, GA 30354). The Owner reserves the right to use its own resources to duplicate monitoring and verify the work required by the Contractor in this section.

### **3.03 REMOVAL OF TEMPORARY SEDIMENT CONTROL STRUCTURES**

- A. At such time that temporary erosion and control structures are no longer required under this item, the Contractor shall notify the Engineer of its intent and schedule for the removal of the temporary structures, and obtain the Engineer's approval in writing prior to removal. Once the Contractor has received such written approval from the Engineer, the Contractor shall remove, as approved, the temporary structures and all sediments accumulated at the removed structure shall be returned upgrade. In areas where temporary control structures are removed, the site shall be left in a condition that will restore original drainage. Such areas shall be evenly graded and seeded as specified in Section 32 90 00 – Final Grading and Landscaping.

### **3.04 NOTICE OF TERMINATION**

- A. When all construction activities have ceased, final stabilization has been implemented by the Contractor, and the site is in compliance with the NPDES Permit, the Contractor, together with the Engineer shall submit a Notice of Termination.

### **3.05 CHECKLIST**

- A. The checklist on the following pages shall be completed as required.



## EROSION, SEDIMENTATION, AND POLLUTION CONTROL CHECKLIST

**Instructions:** Complete this checklist at least once per week and within 24 hours of any rainfall greater than 1/2 inch. Summarize deficiencies on this page (attach additional pages if necessary). Take action to correct problems within 24 hours. Keep this form in the project file.

Inspection Done by: \_\_\_\_\_ Date: \_\_\_\_\_

Item No.	Explanation of Deficiency or Deficiencies	Corrective Action Taken	Date Completed

**END OF SECTION**

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**SECTION 32 10 00**  
**PAVING AND SURFACING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish all labor, equipment and materials and perform all operations in connection with the construction of asphalt concrete pavement, asphalt concrete overlay, reinforced concrete pavement, gravel roads, concrete curb and gutter, repair and reconstruction of existing asphalt concrete pavement, repair of existing gravel roads, and pavement markings complete as specified herein and as detailed on the Drawings.
- B. All new roads including the replacement of portions of the existing roads shall be to the limits, grades, thicknesses and types as shown on the Drawings. Patches for pipe crossings and areas damaged during the construction work shall be asphalt and/or gravel, depending upon the material encountered, unless otherwise indicated.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Requirements of related work are included in Division 01, Division 02 and Division 03 of these Specifications.

**1.03 RELATED SECTIONS**

- A. Section 31 00 01 – Earthwork
- B. Section 03 30 00 – Cast-in-Place Concrete

**1.04 STANDARD SPECIFICATIONS**

- A. Except as otherwise provided in the Specifications or on the plans, all work shall be in accordance with the Georgia Department of Transportation Standard Specifications, latest edition except that any reference to "GDOT", "Department" or "Unit" shall mean the "Owner". When reference to these Specifications is intended, the description will be GDOT Section \_\_\_\_\_ or GDOT Specifications.
- B. Except with the approval of the Engineer, the placing of concrete or asphalt concrete surface paving shall be subject to the Seasonal and Weather Restrictions set forth in GDOT Specifications.

## **PART 2 – MATERIALS**

### **2.01 SELECT FILL**

- A. The Contractor shall place select fill as necessary to complete the embankments, shoulders, subgrade foundation and replacement for removed unsuitable material in accordance with GDOT Section 812, and Section 31 00 01 – Earthwork.

### **2.02 GRAVEL**

- A. All work, including materials, associated with gravel shall be in accordance with GDOT Section 800, Coarse Aggregate.

### **2.03 AGGREGATE STABILIZATION**

- A. All work, including materials, associated with Aggregate Stabilization shall be in accordance with GDOT Section 818, Crushed Aggregate Subbase.

### **2.04 GRADED AGGREGATE BASE (GAB)**

- A. All work, including materials, associated with Graded Aggregate Base shall be in accordance with GDOT Section 815, Graded Aggregate.

### **2.05 ASPHALT BINDER FOR PLANT MIX**

- A. All work, including materials, associated with asphalt binder shall be in accordance with Section 822, Emulsified Asphalt GDOT Standard Specifications.

### **2.06 ASPHALT PAVEMENTS**

- A. All work, including materials, associated with asphalt pavement shall be in accordance with Section 400, Hot Mix Asphaltic Concrete Construction, of the GDOT Standard Specifications. Surface Course shall be 9.5 mm Superpave, Intermediate Course shall be 12.5 mm Superpave, and Base Course shall be 19 mm Superpave. Asphalt pavement mix designs shall be in accordance with Section 828 of the GDOT Standard Specifications.
- B. The job mix formulas shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

### **2.07 RIGID PORTLAND CEMENT CONCRETE PAVEMENT**

- A. All work, including materials associated with rigid concrete pavement shall be in accordance with Section 03 30 00 – Cast-in-Place Concrete. Class A concrete shall be used. Placement shall be in accordance with Section 03 30 00 – Cast-in-Place Concrete and GDOT Section 430, Portland Cement Concrete Pavement.

## **2.08 RIGID CONCRETE PAVEMENT REINFORCING**

- A. Reinforcing, if specified, shall be as shown on the Structural Drawings and as specified under Section 03 21 00 – Reinforcing Steel.

## **2.09 CONCRETE CURB AND GUTTERS**

- A. Concrete shall be Class B in accordance with the requirements of Section 03 30 00 – Cast-in-Place Concrete, except that concrete shall be air-entrained to provide an air content of  $6\% \pm 1.5\%$ .
- B. Premolded expansion joint filler for expansion joints shall conform to ASTM D 1751 and shall be 1/2-inch thick, minimum.

## **2.10 ASPHALT TACK COAT**

- A. All work, including materials, associated with asphalt tack coat shall be in accordance with Section 413, Bituminous Tack Coat, of the GDOT Standard Specifications.

## **PART 3 – EXECUTION**

### **3.01 SUBGRADE**

- A. The subgrade, where shown on the Drawings, shall be aggregate stabilized by the addition and mixing of coarse aggregate with the top 3-inches of subgrade in accordance with GDOT Section 304. Aggregate stabilization shall be applied to the subgrade at a rate of 300-pounds per square yard. Following the application of stabilizer aggregate, the subgrade shall be formed true to crown and grade, and shall be compacted with a minimum of four (4) passes of a 15-ton vibratory roller to conform to the maximum densities determined by AASHTO T99 Standard Specifications.

### **3.02 BASE COURSE**

- A. The finished base course of all paving shall be ABC and shall be of the thickness shown on the Drawings, formed true to crown and grade. Gravel roads, including repair to existing gravel roads shall be ABC and shall be of the thicknesses shown on the Drawings, formed true to crown and grade. No fill material except new ABC shall be placed on top of existing gravel.

### **3.03 ASPHALT BASE COURSE (OR INTERMEDIATE COURSE)**

- A. Asphalt Concrete Base (or Intermediate) Course shall be placed in accordance with GDOT Standard Specifications Section 400. Asphalt Concrete Base (or Intermediate) Course shall be compacted in accordance with GDOT Standard Specification 400. Thicknesses shall be as shown on the Drawings.

### **3.04 ASPHALT CONCRETE SURFACE COURSE**

- A. Prior to placement of the asphalt concrete surface course, the base/intermediate course shall be inspected for damage or defects and repaired to the satisfaction of the Engineer. The surface of the base/intermediate course shall be approved by the Engineer.
- B. The asphalt tack coat shall be applied to the surface of the approved base/binder course as described in GDOT Section 400. Equipment for applying the tack coat shall be power-oriented pressure spraying or distributing equipment suitable for the materials to be applied and approved by the Engineer.
- C. The Asphalt Concrete Surface Course shall be placed and compacted on the base/intermediate course in layers not to exceed 2-inches and at the rate of 110-pounds per square yard per inch. Surface Course shall be compacted in accordance with GDOT Standard Specification 400. Thicknesses shall be as shown on the Drawings.

### **3.05 RIGID PORTLAND CEMENT CONCRETE**

- A. The subgrade and base course beneath portland cement concrete pavement shall be prepared in accordance with the applicable Sections of these Specifications and referenced Standard Specifications, except that the Contractor shall use an approved automatically controlled fine grading machine to produce final subgrade and base surfaces meeting the lines, grades, and cross sections (thicknesses) shown on the Drawings or established by the Engineer.
- B. The surface of the base shall be damp at the time the concrete is placed. The Contractor shall sprinkle the base when necessary to provide a damp surface. The Contractor shall satisfactorily correct all soft areas in the subgrade or base prior to placing concrete.
- C. Hauling over the base course shall not be allowed except where specifically permitted by and in writing by the Engineer. The Engineer may allow equipment dumping concrete to operate on the base to the extent and under the conditions the Engineer deems necessary to facilitate placing and spreading the concrete.
- D. Installation of the rigid concrete pavement shall be in accordance with the details shown on the Drawings and Division 3 - Concrete. The rigid concrete pavement shall cure a minimum of ten (10) calendar days and until the concrete has attained a minimum flexural strength of 550 psi as indicated by flexural strength testing. The Contractor shall coordinate and pay for all flexural strength testing with a minimum of four (4) 6-inch by 6-inch by 20-inch beams for every fifty (50) cubic yards of pavement concrete installed.
- E. Contraction joints shall be spaced at intervals as shown on the Drawings. Transverse contraction joints shall be formed by an approved joint insert. Expansion joints shall be placed when the pavement abuts a structure using 1-inch expansion joint material (filler) and sealant as specified herein.

### **3.06 CONCRETE CURB AND GUTTER**

- A. The expansion joint filler for concrete curb and gutters shall be cut to conform with the cross section of the curb. Expansion joints shall be spaced at intervals of not more than 25-feet. Formed control joints shall be installed at intervals not exceeding 10 feet. Depth of joint shall be 1/3 the thickness. Curved forms shall be used where radii are indicated; straight segments shall not be permitted. Upon removal of the forms, exposed curb faces shall be immediately rubbed down to a smooth and uniform surface. No plastering shall be permitted.

### **3.07 UNDERGROUND UTILITY LINES**

- A. Where an underground utility line is beneath the new roadway, the backfilling shall be carried out with special care, and the final consolidation shall be accomplished by a vibratory roller. Construction of the roadway over the trench shall be deferred as long as practicable.

### **3.08 JUNCTION WITH OTHER PAVING**

- A. Where new asphalt concrete pavement abuts existing asphalt concrete pavement, the existing pavement shall be cut back to insure obtaining the specified compaction of the new pavement courses and interlocking adjoining courses. Existing subbase courses shall be cut back from the subgrade level of the new pavement on a one-on-one slope into the existing pavement, and the asphalt courses of the existing pavement shall be removed for an additional 6-inches back from the slope. The edge of the existing asphalt courses shall be saw cut straight and true. The faces between new and existing asphalt courses shall receive an application of tack coat.
- B. Where new rigid concrete pavement abuts existing rigid concrete or asphalt concrete paving, the existing paving shall be saw cut straight and true. An expansion joint of a 1/2-inch minimum thickness with filler material and sealant shall be placed between the new concrete pavement and the existing rigid concrete or asphalt concrete paving.

### **3.09 ASPHALT CONCRETE OVERLAY**

- A. Where asphalt concrete is proposed to be placed over an existing asphalt or rigid concrete surface, the surfaces shall be thoroughly cleaned by power brooming and a tack coat shall be applied in accordance with GDOT Section 413, Bituminous Tack Coat, of the GDOT Standard Specifications, prior to installing the overlay. The overlay shall be applied in accordance with Subsections 2.06 and 3.05 and Standard Details shown on the Drawings.

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**SECTION 32 11 00**  
**SURFACE RESTORATION**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Provide all labor, equipment, and materials necessary for final grading, topsoil placement, and miscellaneous site work not included under other Sections but required to complete the work as shown on the Drawings and specified herein.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 31 00 01 – Earthwork
- B. Section 31 25 00 – Erosion and Sedimentation Control
- C. Section 32 90 00 – Final Grading and Landscaping

**PART 2 – MATERIALS**

**2.01 TOPSOIL**

- A. Topsoil shall meet the requirements of Section 31 00 01 – Earthwork.

**PART 3 – EXECUTION**

**3.01 FINAL GRADING**

- A. Following approval of rough grading the subgrade shall be prepared as follows:
  - 1. For riprap, bare soil 24 inches below finish grade or as directed by Engineer.
  - 2. For topsoil, scarify 2-inches deep at 4 inches below finish grade.

**3.02 TOPSOIL PLACEMENT**

- A. Topsoil shall be placed over all areas disturbed during construction under any contract except those areas which will be paved, graveled or rip rapped.
- B. Topsoil shall be spread in place for lawn and road shoulder seed areas at a 4-inch consolidated depth and at a sufficient quantity for plant beds and backfill for shrubs and trees.
- C. Topsoil shall not be placed in a frozen or muddy condition.

- D. Final surface shall be hand or mechanically raked to an even finished surface to finish grade as shown on Drawings.
- E. All stones and roots over 4-inches and rubbish and other deleterious materials shall be removed and disposed of.

**END OF SECTION**

**SECTION 32 31 13**  
**STEEL FENCING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install steel fencing, posts, gates, etc., where shown on the Drawings and in compliance with these Specifications.
- B. Fencing shall be of the chain link type topped with barbed wire. The 6-foot high fabric shall clear the final grade by 1 inch and shall be topped with three strands of barbed wire. The barbed wire shall be angled outward at the top. All components which are to be galvanized shall be hot dipped galvanized, coating to be 1.8 ounces per square foot of surface. Alternate coatings which employ a zinc coating of less than 1.8 ounces per square foot are not acceptable.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 03 30 00 – Cast-in-Place Concrete.

**1.03 SUBMITTALS**

- A. Shop Drawings shall be furnished in accordance with Section 01 33 00 – Submittal Procedures.

**PART 2 – PRODUCTS**

**2.01 CHAIN LINK FABRIC**

- A. Fabric shall be 9-gauge aluminum coated wire woven in a 2-inch diamond mesh conforming to ASTM A491. Top and bottom selvage to have a barbed finish. Minimum weight of coating shall be 0.40 ounce per square foot of wire surface. The coated wire shall have a minimum tensile strength of 80,000 lbs. per square inch.
- B. Install fabric 1 inch above ground level. Fence shall be stretched tight and securely fastened to posts at points spaced 12 inches apart maximum.

**2.02 POSTS**

- A. Posts and rails shall be galvanized standard weight pipe conforming to the requirements of ASTM F1083.

1. Line Posts: Line posts shall be Schedule 40, 2-7/8 inch O.D. galvanized pipe with minimum bending strength of 201 pounds under a 6-foot cantilever load. Line posts shall be spaced at a maximum 10-foot O.C.
2. Terminal Posts: All end, corner, intermediate, and pull posts and gate leaves 6'0" wide and less shall be 3-1/2 inch O.D. galvanized Schedule 40 pipe with minimum bending strength of 381 pounds on 6-foot cantilever load. Gate posts for gate leaves shall be Schedule 40 pipe complying with ASTM F1083 of diameters as follows:

Gate Leaf Width	Pipe O.D.	Weight per Ft.
0' to 6'	3-1/2"	9.11 lbs.
Over 6' to 13'	4"	10.79 lbs.
Over 13' to 18'	6-5/8"	18.97 lbs.
Over 18'	8-5/8"	24.7 lbs.

### 2.03 TENSION WIRE

- A. Top and bottom tension wire shall be No. 7 gauge aluminum coated steel wire. Fabric shall be securely tied to tension wire at intervals not to exceed 24-inches.

### 2.04 POST TOPS AND BARBED WIRE SUPPORTS

- A. Gate, end, corner and line post tops shall be malleable iron or pressed steel and shall be hot dipped galvanized conforming to ASTM A153.
- B. Extension arms for supporting the three (3) strands of barbed wire for line posts shall be of pressed steel with malleable iron base, or solid aluminum alloy castings.
- C. Angles for line post extension arms shall be approximately 45 degrees from the vertical and the top slot for barbed wire shall be a minimum of 12 inches above the fabric and a minimum of 10 inches from the fence line.

### 2.05 BARBED WIRE

- A. Barbed wire shall consist of three strands of 12-1/2 gauge aluminum coated steel wire with 4-point barbs of 14 gauge aluminum wire spaced 5 inches apart, conforming to ASTM A585.
- B. Additional strands of barbed wire shall be added beneath the chain link fabric at all ditch crossings to maintain the security of the fence installation.

### 2.06 BRACES AND TOP RAILS

- A. Braces and top rails (where shown on the Drawings) shall be 1.66-inch O.D., Schedule 40 galvanized pipe with minimum vertical bending strength of 202 pounds on 10-foot span.
- B. Top rails shall be continuous and shall pass through the post tops. The coupling used to join the top rail lengths shall allow for expansion. Brace rails shall be provided at all terminal posts, located between the top and grade lines and extend from the terminal post to the first adjacent post. Braces shall be securely fastened at both ends. Brace ends for receiving brace rails shall be malleable iron or castings of 356.0 (formerly SG70A) alloy, or equivalent of ASTM B26 or B108.
- C. Truss and stretcher bands shall be 1/8-inch x 7/8-inch pressed steel, supplied with carriage bolts and nuts. Bolts shall be 5/16-inch by 1 1/4-inch. Truss rods shall be 3/8-inch nominal diameter.

## **2.07 FABRIC TIES**

- A. Wire ties shall be pre-formed 0.148-inch diameter (9 gauge) aluminum. Flat band type ties shall be 1100-H18 or 3003-H14, .064-inch thick by 1/2-inch wide.
- B. Hog rings for attaching tension wire to fabric shall be 0.105-inch diameter, Alloy 1100-H14.

## **2.08 GATES**

- A. Gate frames shall be made of 2-inch O.D. ASTM F1083 pipe, 2.72 lbs. per foot hot dipped galvanized. Fabric shall match fence. Gate frames shall be welded or assembled with riveted corner castings. Gate frames shall be equipped with 3/8-inch diameter adjustable truss bars. Hinges shall be ball and socket.
- B. Gate shall be equipped with positive latching device with provision for padlocking. Personnel gates shall be minimum 36-inch clear opening.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. All line posts shall be spaced equidistant in the fence line on a maximum of 10-foot centers. Posts shall be set plumb in concrete bases as detailed on Drawings. The top of the posts shall be brought to a smooth grade line. The wire fence shall be set accurately to line and grade and shall be plumb.
- B. End, corner, pull or intermediate posts shall be placed in the following locations: corners; changes in direction; abrupt changes in grade; intervals no greater than 500 feet in the fence line. Each end or gate post shall have one brace assembly and each corner or intermediate post shall have two brace assemblies.

- C. Horizontal braces shall be provided at all terminal posts, corner posts, and intermediate posts between top rail and ground and shall extend from the above-mentioned posts to the first adjacent line posts. Braces shall be securely fastened to the line posts by brace ends and brace bands and to the terminal posts by approved rail end connectors. Diagonal brace rods shall be trussed from the brace end on the line post back to the terminal post, corner post or intermediate post and fastened to it by an approved connector.

### **3.02 POST FOUNDATIONS**

- A. Post holes shall be in true alignment and of sufficient size to provide a permanent foundation of concrete. Holes shall be well centered on the posts. A minimum diameter of 12 inches shall be required for all posts.
- B. Post foundations shall be carefully rodded or tamped into place. The top of concrete shall extend 2 inches above ground line and shall be neatly troweled and leveled up from edges to the posts so as to have a pitch outward in all directions.
- C. No materials shall be installed on the posts, nor shall any load be applied to the posts within 3 days after the individual post foundation is completed.
- D. All concrete shall be Class "B" in conformance with Section 03 30 00 – Cast-in-Place Concrete.

### **3.03 RESETTING OF EXISTING FENCE**

- A. Where shown on the Drawings that resetting of existing fence is required, the fence, after resetting, shall be in a condition that is equal to or better than before the fence was removed.
- B. The Contractor shall replace any of the fence components which have been unnecessarily damaged by him.

### **3.04 PADLOCK AND KEYS**

- A. One solid brass padlock shall be furnished with each gate. Padlocks shall be master keyed to the system specified under Section 08 71 00 – Finish Hardware.

### **3.05 TEMPORARY FENCING**

- A. The Contractor shall furnish and install all temporary fencing and appurtenances as shown on the Drawings or as required during construction to adequately secure the site prior to installation of the permanent fence.

**END OF SECTION**

**SECTION 32 90 00**  
**FINAL GRADING AND LANDSCAPING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all labor, equipment, and materials necessary for final grading, topsoiling, seeding, and miscellaneous site work not included under other Sections, but required to complete the work as shown on the Drawings and specified herein. Under this Section, all areas of the project site disturbed by excavation, materials storage, temporary roads, etc., shall be reseeded as specified herein.
- B. Final grading and landscaping shall meet the requirements of the Georgia Soil and Water Conservation Commission's Manual for Erosion & Sediment Control (Green Book), latest edition.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 31 25 00 – Erosion and Sedimentation Control
- B. Section 32 11 00 – Surface Restoration

**1.03 SUBMITTALS**

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures:
  - 1. Product Data
  - 2. Certification of all materials
  - 3. Three (3) copies of composition and germination certification and of test results for grass seed.

**PART 2 – PRODUCTS**

**2.01 CONTRACTOR'S RESPONSIBILITIES**

- A. Furnish and submit certification for the materials used as specified in the General Conditions, Division 01 and Division 2.

**2.02 TOPSOIL**

- A. Upon completion and approval of the rough grading, the Contractor shall place the topsoil over all areas disturbed during construction under any contract except those

areas which will be paved, graveled or rip rapped. Topsoil shall not be placed in a frozen or muddy condition and shall contain no toxic materials harmful to grass growth. Topsoil shall be as defined under Section 31 00 01 – Earthwork.

### **2.03 WATER**

- A. Water shall be furnished to the Contractor by the Owner from existing facilities as directed by the Engineer.
- B. The Contractor shall furnish all hoses and connections necessary to complete the landscaping work.

### **2.04 FERTILIZER**

- A. Fertilizer shall be a complete commercial fertilizer with components derived from commercial sources. Contractor shall furnish fertilizer in accordance with the recommendations of the Georgia Department of Agriculture and the Green Book.
- B. One quarter of the Nitrogen shall be in the form of nitrates, one quarter in the form of ammonia salts, and one half in the form of natural organic Nitrogen. Available Phosphoric Acid shall be free from superphosphate, bone, or tankage. Potash shall be Sulphate of Potash. Elements shall conform to the standards of Association of Official Agricultural Chemists.
- C. Fertilizer shall be delivered in standard size bags marked with the weight, analysis of contents, and the name of the manufacturer. Fertilizer shall be stored in weatherproof storage areas and in such a manner that its effectiveness will not be impaired.

### **2.05 LIME**

- A. At least 50% shall pass a No. 200 U.S.S. mesh sieve. At least 90% shall pass a No. 100 U.S.S. mesh sieve and 100% shall pass a No. 10 U.S.S. mesh sieve. Total carbonates shall not be less than 80% or 44.8% Calcium Oxide equivalent. For the purpose of calculation, total carbonates shall be considered as Calcium Carbonate.

### **2.06 GRASS SEED**

- A. The Contractor shall furnish the kinds and amounts of seed as specified in the Drawings to be seeded in all areas disturbed by the construction work. All seed shall be labeled to show that it meets the requirements of the Georgia Seed Law. All seed must have been tested within six (6) months immediately preceding the planting of such material on the job.
- B. The inoculant for treating legume seed shall be a pure culture of nitrogen-fixing bacteria prepared specifically for the species. Inoculants shall not be used later than the date indicated on the container. The quality of the seed shall conform the Green Book.



- C. All seed shall be in conformance with Georgia Seed Law restrictions for restricted noxious weeds.
- D. Seed mixtures to be used on the project are identified in the Drawings.

## **2.07 TEMPORARY SOIL STABILIZER**

- A. The temporary agent for soil erosion control shall consist of an especially prepared plant-based or cementitious highly concentrated powder which, when mixed with water, forms a thick liquid such as "DustOut" manufactured by DustOut™, "Stabilizer" manufactured by Stabilizer Solutions, or "SoiLok™" as manufactured by Prime Resins, or equal, and having no growth or germination inhibiting factors. The agent shall be used for bare soil stabilization or hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a wind and rain resistant crust.

## **2.08 ROLLED EROSION CONTROL PRODUCTS**

- A. The rolled erosion control products (RECPs) shall be as specified in Section 31 25 00 – Erosion and Sedimentation Control.

## **2.09 RIPRAP AND HERBICIDES**

- A. Furnish and install sufficient quantity of landscape gravel or riprap to cover over the ground to a minimum 4-inch depth for gravel and 24-inch depth for riprap, unless otherwise noted, or indicated on the Drawings. Also furnish and apply an approved herbicide to the subgrade surface just prior to installing the landscape gravel or riprap.
- B. During placing, the stone shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone.
- C. All topsoil and vegetative matter shall be removed from the subgrade surfaces prior to the application of the weed killer (herbicide) and to the placement of landscape gravel or riprap. Apply commercial-type herbicide as preemergence control of miscellaneous grasses and broadleaf weeds in granular or liquid form such as "Treflan", "Dymid", or equal. Methods and rates of application shall be in strict compliance to manufacturer's directions and acceptable to the Engineer.
- D. The herbicide selected shall be safe for use around ornamental plantings, have long-lasting weed control, and shall be resistant to leaching away under excessive rainfall.
- E. A second application of the herbicide shall be made on the surface of the landscape gravel or riprap sometime after the first six (6) months, but not later than 12-months. Same methods and rates apply as specified previously.

## **PART 3 – EXECUTION**

### **3.01 GRADING**

- A. After approval of the rough grading, the Contractor shall commence his preparations of the subgrade for the various major conditions of the work as follows:
  - 1. Bare soil for riprap area at subgrade (24-inches below final grade, or as directed by the Engineer).
  - 2. Topsoil for lawn and road shoulder seed area - scarify 2-inch depth of subgrade (4-inches below final grade) prior to placing topsoil.
- B. Final surface grading of the top-soiled, landscape graveled, and riprapped areas shall be mechanically raked or hand raked to an even finished surface alignment.

### **3.02 TOPSOIL**

- A. Topsoil shall be spread in place for quantity required for lawn and road shoulder seed areas at 4-inch consolidated depth, and sufficient quantity for certain plant beds and backfill for shrubs and trees as specified.

### **3.03 SEEDBED PREPARATION**

- A. Contractor shall prepare all areas to receive temporary or permanent seeding measures prior to planting.
- B. Topsoil shall be placed in areas to be seeded and roughened with tracked equipment or other suitable measures. Slopes steeper than 3:1 may be roughened by grooving, furrowing, tracking, or stairstep grading. Slopes flatter than 3:1 should be grooved by disking, harrowing, raking, operating planting equipment on the contour.
- C. Soil amendments including, but not limited to, lime and fertilizer shall be spread as necessary, and at the rates specified in this Section. Seeding shall be as per the type and rates specified in this Section. Seed shall be broadcast as soon as possible following roughening, before surface has been sealed by rainfall.

### **3.04 HYDROSEEDING AND GRASS**

- A. The Contractor shall grow a stand of grass by hydroseeding method on all disturbed areas. The Contractor shall be responsible for the satisfactory growth of grass throughout the period of the one-year guarantee.
- B. The Contractor's work shall include the preparation of the topsoil and bare soil seed bed, application of fertilizer, limestone, mulching, inoculant, temporary soil stabilizer, watering, and all other operations necessary to provide a satisfactory growth of sod at the end of the one-year maintenance period. Areas without satisfactory sod at the end of

one (1) year shall be replanted until satisfactory growth is obtained and acceptable to the Engineer.

- C. All areas to be seeded shall be done by the hydraulic seeding method including all additives and amendments required. A "Reinco", "Finn", or "Bowie" type hydromulcher with adjustable nozzles and extension hoses, or equal, shall be utilized. General capacity of tank should range from 500 to 2,500 gallons, or as approved by the Engineer.
- D. Hydraulic seeding shall be carried out in three steps. Step one shall consist of the application of lime. In step two the seed mixture shall be mixed with the fertilizer, wood cellulose fiber mulch, and any required inoculants and applied to the seed bed. Step three shall consist of application of top dressing during the first spring or fall, whichever comes first, after step two.
- E. Top dressing shall consist of a commercial grade fertilizer plus Nitrogen or other analysis as may be recommended by soil testing. Types and application rates of seed mixtures, lime, fertilizer, and wood cellulose fiber mulch shall be as shown in the Seeding Schedule.
- F. Ingredients for the mixture and steps should be dumped into a tank of water and thoroughly mixed to a homogeneous slurry and sprayed out under a minimum of 300-350 pounds pressure, in suitable proportions to accommodate the type and capacity of the hydraulic machine to be used. Applications shall be evenly sprayed over the ground surface. The Contractor shall free the topsoil of stones, roots, rubbish, and other deleterious materials and dispose of same off the site. The bare soil, except existing steep embankment area, shall be rough raked to remove stones, roots, and rubbish over 4-inches in size, and other deleterious materials and dispose of same off the site.
- G. No seeding should be undertaken in windy or unfavorable weather, when the ground is too wet to rake easily, when it is in a frozen condition, or too dry. Any bare spots shown in two to three weeks shall be recultivated, fertilized at half the rate, raked, seeded, and mulched again by mechanical or hand broadcast method acceptable to the Engineer.
- H. Areas that have been seeded with a temporary seed mixture shall be mowed to a height of less than 2-inches and scarified prior to seeding with the permanent seed mixture.
- I. The Contractor shall provide, at his own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.
- J. The Contractor shall water newly seeded areas of the lawn and road shoulder mix once a week until the grasses have germinated sufficiently to produce a healthy turf, or unless otherwise directed by the Engineer. Each watering shall provide three (3) gallons per square yard. The Contractor shall furnish all necessary hoses, sprinklers, and connections.

- K. The first and second cutting of the lawn grasses only shall be done by the Contractor. All subsequent cuttings will be done by the Owner's forces in a manner specified by the Contractor.

### **3.05 DITCH AND SWALE EROSION PROTECTION**

- A. All ditches and swales indicated on the Drawings shall be lined with a rolled erosion control product (RECP). The area to be covered shall be properly graded and hydroseeded before the RECP is installed. Installation shall be in accordance with Section 31 25 00 – Erosion and Sedimentation Control.

### **3.06 MAINTENANCE**

- A. The Contractor shall be responsible for maintaining all seeded areas through the end of his warranty period. Maintenance shall include but not be limited to, annual fertilization, mowing, repair of seeded areas, irrigation, and weed control. The Contractor shall provide, at his own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.
- B. Annual fertilization shall consist of an application of 500#/acre of 10-10-10 commercial grade fertilizer, or its equivalent and 60#/acre of nitrogen in early fall, or other analysis as may be determined by soil test. Annual fertilization shall be in addition to top dressing and shall be performed by the Contractor each fall season after planting until the work is substantially complete.
- C. Mowing shall be scheduled so as to maintain a minimum stand height of 4-inches or as directed by the Engineer. Stand height shall be allowed to reach 8 to 10-inches prior to mowing.
- D. All seeded areas shall be inspected on a regular basis and any necessary repairs or reseedings made within the planting season, if possible. If the stand should be over 60% damaged, it shall be re-established following the original seeding recommendations.
- E. Weed growth shall be maintained mechanically and/or with herbicides. When chemicals are used, the Contractor shall adhere strictly to the instructions on the label of the herbicide. No herbicide shall be used without prior approval of the Engineer.

### **3.07 CLEANUP**

- A. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

- B. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

**3.08 SEEDING SCHEDULE**

- A. All seeding and mulching to be completed by the Contractor shall conform to the schedule shown in the drawings. Areas seeded with temporary seed mixtures shall be reseeded by the Contractor at no additional cost to the Owner with permanent seed as directed by the Engineer.
- B. Application rates of seed mixtures, lime, fertilizer, mulch and top dressing are shown in the Drawings.

**END OF SECTION**

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**SECTION 33 05 61  
UTILITY STRUCTURES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Furnish all materials, labor, equipment, and tools required for the design, fabrication, delivery and installment of utility structures and appurtenances in accordance with the Drawings and as specified herein.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 31 00 01 – Earthwork
- B. Section 03 21 00 – Reinforcing Steel
- C. Section 03 15 00 – Concrete Accessories
- D. Section 03 30 00 – Cast-in-Place Concrete
- E. Section 03 40 00 – Precast Concrete
- F. Section 05 56 00 – Castings

**1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
  - 1. ASTM C478 – Specification for Precast Reinforced Concrete Manhole Sections
  - 2. ASTM C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
  - 3. ASTM C990 – Specifications for Joints in Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

**1.04 SUBMITTALS**

- A. Submit samples and/or Shop Drawings in accordance with Section 01 33 00 – Submittal Procedures.

- B. In addition to items listed in Section 03 40 00 – Precast Concrete, Shop Drawings shall include, but not be limited to:
1. Complete layout and installation Drawings and schedules with clearly marked dimensions.
  2. Material certificates on all piping materials.
  3. Structural design calculations sealed by a P.E. registered in the State of Georgia. Design calculations for precast manholes and vaults shall include confirmation structures adequately resist flotation when they are totally empty and subjected to groundwater full height of structure.
  4. Results of leakage test

## **PART 2 – PRODUCTS**

### **2.01 PRECAST MANHOLES, VAULTS, AND METER BOXES**

- A. Precast utility structures shall be furnished with water-stops, sleeves and openings as noted on the Drawings. Box out for wall pipes shall conform accurately to the sizes and elevations of the adjoining pipes. Precast utility structures shall be watertight and conform to the requirements of ASTM C 478 and ASTM C857 with the following modifications there to:
1. Materials shall conform to Section 03 40 00 – Precast Concrete.
  2. Manholes shall meet the following:
    - a. Manhole section shall have an internal diameter of 4'-0", unless noted otherwise. Clear lid openings shall be 24-inch diameter.
    - b. Minimum manhole wall thicknesses shall be 5 inches for 4-foot and 5-foot diameter manholes, 6 inches for 6-foot diameter manholes and 7 inches for 7-foot diameter manholes.
    - c. Manholes and utility structures shall include ballast concrete and/or other means necessary to ensure manholes resist flotation when empty and subjected to groundwater full height of structure.
    - d. Precast manholes and utility structures shall be as manufactured by Oldcastle, Tindall Corporation, or equal.
  3. The date and name of manufacturer shall be marked inside each precast section.
  4. No more than two lift holes may be cast or drilled in each section.



5. Dimensions shall be as shown on the Drawings.
  6. Covers and frames shall be as specified in Paragraph 2.13.
  7. Mechanical Details such as piping, electrical, and other details shall be as shown on the Drawings.
- B. Joints between manhole and utility structures riser sections and at base slabs shall be groove type.

## **2.02 BRICK**

- A. Brick shall be sound, hard-burned common brick conforming to ASTM C32, Grade MS.

## **2.03 MORTAR**

- A. Mortar shall conform to Section 04 05 13 – Mortar and Masonry Grout.

## **2.04 CONCRETE**

- A. Concrete shall conform to Section 03 30 00 – Cast-in-Place Concrete.

## **2.05 REINFORCING**

- A. Reinforcing shall conform to Section 03 21 00 – Reinforcing Steel.

## **2.06 PRECAST CONCRETE**

- A. Precast concrete shall conform to Section 03 40 00 – Precast Concrete.

## **2.07 CONCRETE BLOCK**

- A. Concrete block shall be solid, rectangular concrete masonry units conforming to ASTM C139.

## **2.08 CASTINGS**

- A. Castings shall conform to Section 05 56 00 – Castings. Casting shall be of the type and size indicated on the Drawings.

## **2.09 STEPS**

- A. Steps shall be constructed of Grade 60 steel reinforcing rod (min. 1/2-inch) and completely encapsulated with a wear resistant and chemical resistant rubber.
- B. Each step shall have a minimum vertical load resistance of 800 pounds and a minimum pull-out resistance of 400 pounds.

- C. The steps shall have 11-inch minimum tread width and shall be placed at 16-inches on center, as shown on the Drawings.
- D. Steps shall be cast in place with the concrete.
- E. Steps shall only be installed as shown on the Drawings or required in the Specifications.

## **2.10 JOINT SEALANT**

- A. Joint sealant shall be a preformed flexible sealant conforming to the requirements of ASTM C990, paragraph 6.2, Butyl Rubber Sealant. Joint sealant shall be Pro-Stik Butyl Sealant by Press-Seal Corporation, Butyl-Nek Join Sealant by Henry Company, CS-102 Butyl Rubber Sealant for all Precast Structures by ConSeal Concrete Sealants, Inc., or equal.

## **2.11 PIPE TO MANHOLE CONNECTIONS**

- A. The spring set type shall have a stainless steel interior power sleeve or expander and shall be the PSX assembly by Press-Seal Gasket Corporation, the Kor-N-Seal® | 106-406 Series assembly by National Pollution Control Systems, or QUIK-LOK Boot Connector by A-LOK Products, Inc, or equal.
- B. The cast-in-place type shall conform to ASTM C923-18 for sanitary sewer connections between reinforced concrete manhole structures, pipes, and laterals, ASTM C1478-19 for storm drain connections between pipes, and laterals, and ASTM F2510 for storm drain connections between reinforced concrete manhole structures, and dual and triple-wall polyethylene and polypropylene pipes. Sleeves shall include stainless steel take up clamps.
- C. Flexible seal assemblies shall permit at least an eight (8) degree deflection from the center line of the opening in any direction while maintaining a watertight connection.

## **2.12 COVERS AND FRAMES**

- A. Covers and frames shall comply with Section 05 56 00 – Castings and shall be provided by the utility structure manufacturer.
- B. Manhole covers and frames shall meet the following requirements:
  - 1. Locate so that there is ready access to the manhole steps
  - 2. Clear opening shall be a minimum of 22 inches, unless otherwise indicated on the Drawings.
  - 3. Watertight manhole frames and covers shall be suitable for 20 psi internal pressure and shall be Neenah Model R-1915, Type E or equal, cast in place.

4. Non-watertight manhole covers shall be perforated and shall be Neenah Model R-1668, or equal.
  5. Storm drain grated inlet frames and grates shall be Neenah R-1878-B7G, East Jordan Iron Works V5660, or equal.
  6. Curb inlet frames and grates shall be Neenah R-3067, East Jordan Iron Works EJ 7030, or equal, and shall include frame, grate, and hood.
- C. Vault covers shall have lifting handles and shall be bolted with stainless steel bolts complying with Section 05 05 23 – Metal Fastening.
  - D. Frames and covers shall be identical throughout the Contract.

### **2.13 GRATES**

- A. Grates shall comply with Section 05 56 00 – Castings.

### **2.14 CONCRETE BALLAST**

- A. Concrete ballast shall be Class B concrete in conformance with Section 03 30 00 – Cast-in-Place Concrete. Ballast shall be provided as necessary to insure manhole resists flotation when empty and subjected to full height groundwater conditions.

### **2.15 FLEXIBLE JOINT SEALER**

- A. Flexible joint sealer shall be a rubber ring waterstop as manufactured by Fernco Joint Sealer Co., or equal.

### **2.16 EPOXY BONDING AGENT**

- A. Epoxy bonding agent shall conform to Section 03 15 00 – Concrete Accessories.

## **PART 3 – EXECUTION**

### **3.01 DESIGN CRITERIA**

- A. Minimum structural design loading for underground precast concrete vaults shall be as indicated in ASTM C857, unless otherwise noted herein. Precast items subjected to vehicular traffic shall be designed for H-20 traffic loading. Other precast items shall be designed for a vertical live load of 300 psf.
- B. Walls of precast items shall be designed for a vertical surcharge of 100 psf.
- C. Precast manholes and vaults shall be designed to resist flotation when totally empty and subjected to groundwater full height of the manhole/vault.

### **3.02 FABRICATION AND CASTING**

- A. Fabrication and casting shall conform to Section 03 40 00 – Precast Concrete, and to Section 03 30 00 – Cast-in-Place Concrete.
- B. All base sections designated to receive concrete ballast and all electrical manholes shall extend monolithically a minimum of 6 inches beyond the outside face of the wall for the entire periphery. All other utility structures shall have a standard base.
- C. Utility structures built around existing pipe shall have a cast-in-place base slab.

### **3.03 HANDLING, TRANSPORTING, AND STORING**

- A. Handling, transporting and storing of precast items shall comply with Section 03 40 00 – Precast Concrete.

### **3.04 INSTALLATION**

- A. Installation shall conform with Section 03 40 00 – Precast Concrete and with the manufacturer's recommendations or to Section 03 30 00 – Cast-in-Place Concrete.
- B. Frames and covers or grates shall be set so that tops are at elevations indicated on the Drawings or flush with finished grade where no elevation is indicated.
- C. Joints between riser sections shall be sealed with joint sealant.
- D. All openings in utility structures shall have flexible rubber sleeves sized to fit the connecting pipe and installed to provide watertight joints in accordance with the manufacturer's recommendations. The interior of the sleeve shall be filled with Class B concrete.
- E. Openings that are too large for flexible rubber sleeves shall utilize rubber bladder seals which are expanded by water injected using a pressure pump.
- F. All units shall be installed plumb and level.
- G. All lift holes and joints shall be filled with non-shrink grout conforming to Section 03 60 00 – Grout, grout inside and out.
- H. The manhole frames shall be set to their required elevations either with grade rings or with two or three courses of brick masonry laid around the top of the upper wall section. Such brick work shall be given a 1-inch mortar coat on the inside and out.
- I. Concrete ballast shall be placed so that it bears directly on the utility structure base against the outer wall monolithically encircling the structure for the full height indicated on the Drawings. Additional ballast may be required where the depth or elevation of the structure varies from the Drawings.

J. Brick or Concrete Block

1. Brick or concrete block shall be laid with broken joints and all horizontal and vertical joints filled with cement-sand mortar. Outside of walls shall be plastered with a minimum 1-inch thick coat of cement-sand mortar troweled smooth.

K. Connection to Existing Pipe

1. Verify the diameter and invert elevation of existing pipe to be connected to new utility structures prior to beginning work on the structures.
2. Provide adequate protection to prevent damage to the existing pipe.
3. Provide adequate means for plugging and/or transferring the existing flow in the pipe to allow for the construction of inverts and grouting.
4. Cut off the existing pipe sufficiently for connection to the new structure and remove.
5. Thoroughly clean all foreign matter and coat the pipe surface with epoxy adhesive where the pipe joins the new structure.
6. Install a flexible joint sealer around the pipe.
7. Grout inside and outside of wall penetration with non-shrink grout.

L. Backfill structures in accordance with Section 31 00 01 – Earthwork.

M. Clean all structures of any accumulation of silt, debris, or foreign matter and keep clean until final acceptance of the work.

N. Excavation shall conform to Section 31 00 01 – Earthwork.

O. Structure bases shall bear on a minimum of 8-inches of compacted stone unless otherwise indicated on the Drawings.

P. Channel Inverts

1. Inverts shall be placed using Class B concrete with forms sufficient to provide a smooth half-round shape as shown on the Drawings. Manhole bases employing full depth precast inverts are acceptable.
2. Where the slope of the line does not change through a manhole, a constant slope shall be maintained in the invert. Where slope changes occur within a given manhole, the transition shall be smooth and shall occur at the approximate center of the manhole.

3. Inverts shown on the Drawings are taken at the center of the manhole unless otherwise noted.

### **3.05 ADJUSTMENTS TO EXISTING UTILITY STRUCTURES**

- A. Adjust structures as indicated on the Drawings using concrete or cast iron adjustment rings by approved methods.
- B. Clean covers and inlet castings of all foreign material.

### **3.06 ADJUSTING COLLARS AND FINAL ADJUSTMENTS**

- A. Adjusting collars shall be as shown on the Drawings, or as necessary meet final grade. Final adjustments shall be made so that the manhole ring and cover will be smooth and flush with the finished grade of the adjacent surface, or as otherwise indicated on the Drawings for manholes shown above grade.

### **3.07 LEAKAGE TESTING FOR MANHOLES**

- A. All manholes shall be vacuum tested as specified below. Refer to Section 22 14 00 – Storm Drains and Roof Drains for storm water pipe testing methods and requirements and Section 45 05 00 – Basic Mechanical Requirements for sanitary pipe testing methods and requirements.
- B. Manhole vacuum testing shall include the following minimum requirements:
  1. Testing shall be done in accordance with ASTM C1244-05 (or latest revision).
  2. Prior to testing all pipes, holes, and vents entering manhole shall be plugged and braced.
  3. Contractor shall have an approved test head and copy of instructions for use by the manufacturer.
  4. Contractor shall furnish two (2) certified and calibrated vacuum test gauges for the test.

A vacuum of 10-inch hg shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time for the vacuum pressure to drop to 9-inch hg shall be measured. If the test time meets or exceeds the test time as specified in Table 1, the manhole is acceptable; otherwise, the test has failed and the manhole should be checked for leaks, repaired, and re-tested.

**Table 1**  
**Minimum Vacuum Test Times (Seconds) for Various Manhole Diameters and Depths**

<b>Manholes Ø (inches)</b>							
<b>Depth (ft)</b>	<b>48</b>	<b>60</b>	<b>72</b>	<b>84</b>	<b>96</b>	<b>108</b>	<b>120</b>
<b>6'</b>	15	20	25	29	34	38	43
<b>8</b>	20	26	33	38	45	51	57
<b>10</b>	25	33	41	48	56	63	71
<b>12</b>	30	39	49	57	67	76	85
<b>14</b>	35	46	57	67	78	89	100
<b>16</b>	40	52	67	76	89	101	114
<b>18</b>	45	59	73	86	100	114	128
<b>20</b>	50	65	81	95	111	126	142
<b>22</b>	55	72	89	105	122	139	156
<b>24</b>	59	78	97	114	133	152	170
<b>26</b>	64	85	105	124	144	164	185
<b>28</b>	69	91	113	133	155	177	199
<b>30</b>	74	98	121	143	166	189	213
<b>Add. VF</b>	+2.5	+3.25	+4.0	+4.75	+5.5	+6.5	+7.0

### **3.08 FLUSHING AND TESTING OF SEWERS**

A. After backfilling, all sewers shall be inspected for obstructions and shall be flushed with water. Flushing shall be a minimum velocity of 2.5 feet per second for a duration acceptable to the Engineer. Flushing shall remove all dirt, stones, pieces of wood and other debris which accumulated in the sewer during construction. The Contractor shall provide a means acceptable to the Engineer for removal of debris flushed from each section of sewer. If after flushing, any obstructions remain, they shall be removed at the Contractor's expense.

B. Visual Inspection – Sewer lines shall be visually inspected from every manhole by use of mirrors, television cameras, or other devices for visual inspection, and the lines shall all exhibit a fully circular pattern when viewed from one manhole to the next. Lines which do not exhibit a true line and grade or have structural defects shall be corrected to meet these qualifications. Any visual water infiltration of water into the manhole shall be repaired using hydraulic cement or other approved materials.

C. Leakage – Sewers shall be tested for leakage. The program of testing shall fit the conditions as mutually determined by the Engineer and the Contractor. The Contractor shall take all necessary precautions to prevent any joints from drawing while the sewers or their appurtenances are being tested. The Contractor shall, at his own expense, correct any excess leakage and repair any damage to the pipe and their appurtenances, or to any structures resulting from or caused by these tests.

D. Leakage Test Procedure – Each section of sewer shall be tested by closing the lower end of the sewer to be tested and the inlet sewer of the upper manhole with stoppers and filling the pipe and manhole with water to a point 6 feet above the crown of the open

sewer in the upper manhole, or, if ground water is present, 6 feet above the sections average adjacent ground water level as indicated by a monitor well installed adjacent to each manhole. The line shall be filled with water prior to testing and allowed to stand until the pipe has reached its maximum absorption, but not less than two (2) hours. After maximum absorption has been reached, the head shall be reestablished and tested for at least six (6) hours maintaining the head specified above by measured additions of water. The sum of these additions shall be the leakage for the test period.

1. If ground water is present to a height of at least 6 feet above the crown of the sewer at the upper end of the pipe section to be tested, the leakage test may be made by measuring the rate of infiltration using a suitable weir or other measuring device approved by the Engineer. Whether the test is made by infiltration or exfiltration, the allowable leakage shall not exceed 100 gallons per day per inch of diameter per mile of sewer being tested.
  2. Where the actual leakage exceeds the allowable, the Contractor shall discover the cause and correct it before the sewer will be accepted. For the purpose of this subsection, a section of sewer is defined as that length of sewer between successive manholes or special structures or stub-outs for future connections.
- E. Low Pressure Compressed Air Test – If the leakage cannot be located by infiltration or exfiltration testing, this type test may be used. The pipeline shall be considered acceptable, when tested at an average pressure of 3.0 psi greater than the average back pressure of any groundwater that may submerge the pipe, if the section under test does not lose air at a rate greater than 0.0030 cfm per sq. ft. of internal pipe surface.
- F. Deflection Test – No sooner than thirty (30) days after final backfill installation, each section of PVC pipe shall be checked for vertical deflection using an electronic deflectometer or a rigid "GoNoGo" device. Vertical deflection shall not exceed five (5) percent of the inside pipe diameter for PVC pipe.
1. Where the actual deflection exceeds the allowable, the Contractor shall discover the cause and correct it before the pipe will be acceptable. For the purpose of this subsection, a section of sewer is defined as that length of sewer between successive manholes or special structures or stubouts for future connections.
- G. Cost of Testing and Repairs – Any and all work necessary to bring the line into conformance with the infiltration and deflection specifications shall be performed by the Contractor at no extra cost to the Owner. All apparent sources of infiltration and excessive deflection shall be repaired by the Contractor.
1. The Contractor shall provide all water, plugs, hoses, pumps, equipment, etc. necessary for the proper flushing and testing of the sewers.

## END OF SECTION



**SECTION 33 71 19**  
**UNDERGROUND ELECTRICAL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install underground duct systems, electric manholes, and electric handholes as specified herein and as indicated on the Drawings. The work shall be complete and shall include excavation, concrete construction, backfilling, and all materials, items, and components required for a complete system.
- B. The provisions of this Division are applicable to all underground conduit work. All work shall be coordinated with that of the various utility companies and other Contractors. The Contractor shall adhere to all utility company requirements including the serving electric utility.
- C. Reference Section 26 05 00 – Basic Electrical Requirements; Section 26 05 33.13 – Conduit for Electrical Systems; Section 26 05 26 – Grounding and Bonding for Electrical Systems; the applicable sections of Division 31, Earthwork and Division 32, Exterior Improvements; Section 03 21 00 – Reinforcing Steel; and 03 30 00 – Cast-In-Place Concrete.

**1.02 CODES AND STANDARDS**

- A. Products specified herein shall be designed, manufactured, and/or listed to the following standards as applicable:
  - 1. AASHTO H20
  - 2. ANSI/SCTE 77-2010 – Specification for Underground Enclosure Integrity

**1.03 SUBMITTALS**

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit Shop Drawings. Each submittal shall be identified by the applicable Specification Section.

**1.04 SHOP DRAWINGS**

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to, the following:
  - 1. Product data sheets.
  - 2. Outline and dimensional drawings including detailed sections of the manholes and/or handholes.
  - 3. Materials specifications and structural calculations for the manholes sealed by a Professional Engineer in the Georgia.

### **1.05 IDENTIFICATION**

- A. Each electric manhole and handhole cover shall be lettered with the word “Electric”, the manhole or handhole identification number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings.

### **2.02 DUCT SYSTEM**

- A. The underground duct system shall be comprised of conduits, conduit bends, and conduit fittings as specified in Section 26 05 33.13 – Conduit for Electrical Systems. Conduits shall be encased in reinforced concrete envelopes, unless otherwise specified herein or indicated on the Drawings.
- B. Base and intermediate conduit spacers shall be furnished to provide a minimum of two-inch (2”) separation between conduits. Conduit spacers shall be provided in the proper size as required for the conduit that they secure. For example, a 4” conduit spacer shall not be used to secure a 2” conduit. Conduit spacers shall be as manufactured by Carlon Electrical Products Company, Aeroquip Corporation, Underground Devices, Incorporated, or equal.

### **2.03 ELECTRIC MANHOLES**

- A. The concrete manholes shall be complete with metal frames and covers of size and location as specified herein and shown on the Drawings.

- B. Manhole frames and covers shall be Neenah R-1640C1, or equal, with Type A anchor ring. Entire manhole assembly shall be AASHTO H20 heavy duty rated. Covers shall be furnished with drop handles.
- C. All electric manholes shall be provided with non-metallic cable racks. Cable racks shall be rated for the application, with a minimum loading capacity of 450lbs per rack arm. Cable rack system shall be Heavy Duty type as manufactured by Underground Devices, Incorporated or equal.

## **2.04 ELECTRIC HANDHOLES**

- A. The electric handholes shall be a precast polymer concrete enclosure suitable for use as part of an underground electric raceway system. The enclosure shall meet or exceed the requirements of ANSI/SCTE 77-2010.
- B. The enclosure and cover design and test load rating shall be Tier 15. Covers shall be provided with cover hooks.
- C. The enclosure shall be the straight side design to allow easy adjustment of box to grade. The box shall be stackable for increased depth.
- D. Handhole opening size shall be as required to suit the application, 6" X 8", minimum.
- E. The electric handholes shall be manufactured by Hubbell, Pencil Plastics equivalent, Highline Products equivalent, or equal.

## **PART 3 – EXECUTION**

### **3.01 GENERAL**

- A. The underground duct system, manholes, and handholes shall be installed as specified herein, indicated on the Drawings, and in accordance with manufacturers' instructions.

### **3.02 DUCT SYSTEM**

- A. All underground conduit shall be encased in concrete and shall be reinforced. Encasement and reinforcement shall be as indicated in the standard details. Concrete shall be furnished and installed in accordance with Section 03 30 00 – Cast-In-Place Concrete. Reinforcing steel shall be furnished and installed in accordance with Section 03 21 00 – Reinforcing Steel.
- B. Concrete pours shall be complete from handhole to handhole and from manhole to manhole where practicable. Partial pours in general shall not be permitted. Where a complete pour is impractical, written authorization shall be obtained from the Engineer for the partial pour.

- C. Conduit ductbank elevations at the manholes and handholes shall be based on minimum ductbank cover as indicated in the standard details, or deeper to avoid conflicts with other obstacles. Where deviation is necessary to clear unforeseen obstacles, the elevations may be changed after authorization by the Engineer.
- D. Slope all conduits continuously away from structures and buildings with a minimum slope of 3" per 100' unless otherwise indicated on the Drawings.
- E. The minimum clearance from the top of the concrete encasement and finished grade shall be as indicated in the standard details, except where otherwise accepted in writing by the Engineer or shown on the Drawings.
- F. Care shall be exercised during excavation for the duct banks to prevent digging too deep. Backfilling of low spots with earth fill will not be permitted unless thoroughly compacted and acceptable to the Engineer.
- G. If a specific ductbank arrangement is shown on the Drawings, the conduits in that ductbank shall be arranged as shown. Where no specific ductbank arrangement is shown on the Drawings, the Contractor shall arrange conduits within each ductbank based on field conditions. Spare conduits shown going from ductbanks into buildings or structures shall be stubbed up in the location(s) as indicated on the Drawings.
- H. A minimum of one (1) ground rod, furnished in accordance with Section 26 05 26 – Grounding and Bonding for Electrical Systems, shall be driven adjacent to each manhole, handhole, or other concrete box. A No. 4/0 AWG bare copper ground cable shall be connected between this rod and the copper ground strap using a silicon bronze connector. All ground rods shall be interconnected by means of the No. 4/0 AWG bare copper ground cable located within each duct bank. The ends of these cables shall also be connected to substation and/or building ground buses where the conduits terminate.
- I. Care shall be exercised and temporary plugs shall be installed during installation to prevent the entrance of concrete, mortar, or other foreign matter into the conduit system. Conduit spacers shall be utilized to support conduit during the pouring of concrete to prevent movement and misalignment of the conduits. Conduit spacers shall be installed in accordance with manufacturer's instructions unless otherwise noted. Horizontal spacing of conduit spacers along ductbank shall be as indicated on the Standard Details.
- J. Where connections to existing underground conduits are indicated, excavate to the maximum depth necessary. After addressing the existing conductors, cut the conduits and remove loose concrete from the conduits before installing new concrete encased ducts. Provide a reinforced concrete collar, poured monolithically with the new duct line, to take the shear at the joint of the duct lines.
- K. Construct concrete-encased conduits connecting to underground structures to have a flared section adjacent to the manhole to provide shear strength. Construct underground structures to provide shear strength. Construct underground structures to provide for keying the concrete encasement of the duct line into the wall of the structure. Use

vibrators when this portion of the encasement is poured to ensure a seal between the encasement and the wall of the structure.

- L. Six (6) inches above all duct banks, the Contractor shall furnish and install a two (2) inch wide red plastic electrical hazard tape. Tapes shall be metallic detectable type and shall have a continuous message in bold black letters: "ELECTRIC LINE BURIED BELOW." Tape shall be Detectable Identoline by Brady, or equal.
- M. The Contractor shall perform all earthwork including excavation, backfill, bedding, compaction, shoring and bracing, grading and restoration of surfaces and seeded areas disturbed during the execution of the work.
- N. All conduit joints in the duct system shall be staggered such that adjacent conduits do not have joints in the same location.

### **3.03 ELECTRIC MANHOLES**

- A. Electric manholes shall be installed to a sufficient depth to accommodate the required grading of ducts as well as maintaining a minimum distance of 14" from the bottom of the lowest duct centerline entrances to finished floor line and/or highest duct centerline entrance to the roof. All manholes shall be built on or placed over a 6" layer of well-tamped gravel.
- B. Duct envelopes and conduit with bell ends shall enter at approximately right angles to the walls, except as may otherwise be shown on the Drawings.
- C. All concrete work and fully assembled manholes shall be completely watertight and shall be furnished with sloped floors that pitch towards a drain. The outside surfaces shall be coated with an approved asphaltic waterproofing compound (all sides, bottom, and roof). Precast concrete manholes may be installed; however, all requirements of this section and other divisions of the Specifications and the details shown on the Drawings shall apply.
- D. Install pulling eye irons imbedded in walls opposite each duct entrance securely fastened to manhole reinforcing rods. All hardware shall be hot-dipped galvanized steel. Copper bars shall be provided in the walls for grounding. No. 4/0 AWG bare copper cables shall be connected to these bars and all non-current carrying metal parts shall be grounded to these copper bars.
- E. All cables shall be well supported on walls by nonmetallic cable racks. The cable racks shall be heavy-duty type for medium and low voltage power cables and light duty type for control, signal, communications and similar small conductors. All racks shall be rigidly attached to the wall and equipped with adjustable rack arms.

### **3.04 ELECTRIC HANDHOLES**

- A. Electric handholes shall be installed to a sufficient depth to accommodate the required grading of ducts as well as maintaining a minimum distance of 9" from the bottom of the lowest duct centerline entrances to finished floor line and/or highest duct centerline entrance to roof. All handholes shall be built on or placed over a 6" layer of well-tamped gravel.
- B. Duct envelopes and conduit with bell ends shall enter at approximately right angles to the walls, except as may otherwise be shown on the Drawings.
- C. All fully assembled handholes shall be completely watertight.
- D. All individual cables and/or bundles of conductors shall be identified and "dressed" along the wall of the enclosure. Cable racks as specified herein shall be provided if any handhole dimension exceeds 24 inches.

### **3.05 TESTING**

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
  - 1. Field tests
    - a. Field tests for all completed duct systems shall consist of pulling a swab through each conduit followed by a mandrel equal in size to 85% of the conduit inside diameter.
    - b. After testing, all conduits shall be capped after installation of a suitable pull rope. All field tests shall be witnessed by the Engineer.

**END OF SECTION**

**SECTION 40 05 00**  
**BASIC MECHANICAL REQUIREMENTS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install to the required line and grade, all piping together with all fittings and appurtenances, required for a complete installation. All piping located outside the face of structures or building foundations and all piping embedded in concrete within a structure or foundation shall be considered exterior piping.
- B. The Contractor shall furnish and install fittings, couplings, connections, sleeves, adapters, harness rods and closure pieces as required to connect pipelines of dissimilar materials and/or sizes herein included under this Section and other concurrent Contracts for a complete installation.
- C. The Contractor shall furnish all labor, materials, equipment, tools, and services required for the furnishing, installation and testing of all piping as shown on the Drawings, specified in this Section and required for the Work. Piping shall be furnished and installed of the material, sizes, classes, and at the locations shown on the Drawings and/or designated in this Section. Piping shall include all fittings, adapter pieces, couplings, closure pieces, harnessing rods, hardware, bolts, gaskets, wall sleeves, wall pipes, hangers, supports, and other associated appurtenances for required connections to equipment, valves, or structures for a complete installation.
- D. Piping assemblies under 4-inch size shall be generally supported on walls and ceilings, unless otherwise shown on the Drawings or ordered by the Engineer, being kept clear of openings and positioned above "headroom" space. Where practical, such piping shall be run in neat clusters, plumb and level along walls, and parallel to overhead beams.
- E. The Contractor shall provide taps on piping where required or shown on the Drawings. Where pipe or fitting wall thicknesses are insufficient to provide the required number of threads, a boss or pipe saddle shall be installed.
- F. The work shall include, but not be limited to, the following:
  - 1. Connections to existing pipelines.
  - 2. Test excavations necessary to locate or verify existing pipe and appurtenances.
  - 3. Installation of all new pipe and materials required for a complete installation.
  - 4. Cleaning, testing and disinfecting as required.

## **1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Division 01 – General Requirements
- B. Division 02 – Existing Conditions
- C. Division 05 – Metals
- D. Division 09 – Finishes
- E. Division 26 – Electrical
- F. Division 46 – Water and Wastewater Equipment

## **1.03 MATERIAL CERTIFICATION AND SHOP DRAWINGS**

- A. The Contractor shall furnish to the Owner (through the Engineer) a Material Certification stating that the pipe materials and specials furnished under this Section conform to all applicable provisions of the corresponding Specifications. Specifically, the Certification shall state compliance with the applicable standards (ASTM, AWWA, etc.) for fabrication and testing.
- B. Shop Drawings for major piping (2-inches in diameter and greater) shall be prepared and submitted in accordance with Section 01 33 00 – Submittals. In addition to the requirements of Section 01 33 00 – Submittals, the Contractor shall submit laying schedules and detailed Drawings in plan and profile for all piping as specified and shown on the Drawings.
- C. Shop Drawings shall include, but not be limited to, complete piping layout, pipe material, sizes, class, locations, necessary dimensions, elevations, supports, hanger details, pipe joints, and the details of fittings including methods of joint restraint. No fabrication or installation shall begin until Shop Drawings are approved by the Engineer.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. All specials and every length of pipe shall be marked with the manufacturer's name or trademark, size, class, and the date of manufacture. Special care in handling shall be exercised during delivery, distribution, and storage of pipe to avoid damage and unnecessary stresses. Damaged pipe will be rejected and shall be replaced at the Contractor's expense. Pipe and specials stored prior to use shall be stored in such a manner as to keep the interior free from dirt and foreign matter.
- B. Testing of pipe before installation shall be as described in the corresponding ASTM or AWWA Specifications and in the applicable standard specifications listed in the following sections. Testing after the pipe is installed shall be as specified in Part 3.



- C. Joints in piping shall be of the type as specified in the appropriate Piping System Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
- D. ALL BURIED EXTERIOR PIPING SHALL HAVE RESTRAINED JOINTS FOR THRUST PROTECTION UNLESS OTHERWISE SPECIFIED OR SHOWN ON THE DRAWINGS. ALL EXPOSED EXTERIOR PIPING SHALL HAVE FLANGED JOINTS, UNLESS OTHERWISE SPECIFIED OR SHOWN ON THE DRAWINGS.
- E. The Drawings indicate work affecting existing piping and appurtenances. The Contractor shall excavate test pits as required of all connections and crossings which may affect the Contractor's work prior to ordering pipe and fittings to determine sufficient information for ordering materials. The Contractor shall take whatever measurements that are required to complete the work as shown or specified.

**2.02 WALL PIPES**

- A. Where wall sleeves or wall pipes occur in walls that are continuously wet on one or both sides, they shall have water stop flanges at the center of the casting or as shown on the Drawings. Ends of wall pipes shall be flange, mechanical joint, plain end, or bell as shown on the Drawings, or as required for connection to the piping. Wall pipes shall be of the same material as the piping that they are connected to. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange. Unless otherwise shown on the Drawings, waterstop flanges shall conform to the minimum dimensions shown below:

<b>Pipe Size</b>	<b>Waterstop Flange Diameter</b>	<b>Waterstop Flange Thickness</b>
4" - 12"	OD + 3.10"	0.50"
14" - 24"	OD + 4.15"	0.75"
30" - 36"	OD + 4.50"	1.00"
42" - 48"	OD + 5.00"	1.25"
54"	OD + 5.90"	1.50"

**2.03 SLEEVES**

- A. Unless shown otherwise, all piping passing through walls and floors shall be installed in sleeves or wall castings accurately located before concrete is poured or placed in position during construction of masonry walls. Sleeves passing through floors shall extend from the bottom of the floor to a point 3 inches above the finished floor, unless shown otherwise. Water stop flanges are required on all sleeves located in floors or walls which are continually wet or under hydrostatic pressure on one or both sides of the floor or wall.

- B. Sleeves shall be cast iron, black steel pipe, or fabricated steel in accordance with details shown on the Drawings. If not shown on the Drawings, the Contractor shall submit to the Engineer the details of sleeves he proposes to install; and no fabrication or installation thereof shall take place until the Engineer's approval is obtained. Steel sleeves shall be fabricated of structural steel plate in accordance with the standards and procedures of AISC and AWS. Steel sleeve surfaces shall receive a commercial sandblast cleaning and then be shop painted in accordance with Section 09 90 00 – Painting.
- C. When shown on the Drawings or otherwise required, the annular space between the installed piping and sleeve shall be completely sealed against a maximum hydrostatic pressure of 20 psig. Seals shall be mechanically interlocked, solid rubber links, trade name "Link-Seal", as manufactured by Garlock Pipeline Technologies (GPT) or equal. Rubber link, seal-type, size, and installation thereof, shall be in strict accordance with the manufacturer's recommendations. For non-fire rated walls and floors, pressure plate shall be glass reinforced nylon plastic with EPDM rubber seal and 304 stainless steel bolts and nuts. For fire rated walls and floors, two independent seals shall be provided consisting of low carbon steel, zinc galvanized pressure plates, silicon rubber seals and low carbon steel, zinc galvanized bolts and nuts.
- D. Cast iron mechanical joint adapter sleeves shall be Clow # 1429, as manufactured by the Clow Corp., or equal. Mechanical joint adapter sleeves shall be provided with suitable gasket, follower ring, and bolts to affect a proper seal. In general, sleeves installed in walls, floors, or roofs against one side of which will develop a hydrostatic pressure, or through which leakage of liquid will occur, shall be so sealed. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange.

#### **2.04 SOLID SLEEVE COUPLINGS (FOR BURIED SERVICE THROUGH 54-INCH)**

- A. Solid sleeve couplings shall be used to connect buried service piping where shown on the Drawings. Solid sleeves shall be ductile iron, long body and shall conform to the requirements of ANSI A21.10 (AWWA C110). Unless otherwise shown or specified, solid sleeve couplings shall be Style A11760 as manufactured by American Cast Iron Pipe Co., or equal. Solid sleeve couplings shall be restrained with wedge-type restraining glands.
- B. Alternatively, EBAA Iron 3800 Mega-Coupling is acceptable.

#### **2.05 SLEEVE TYPE COUPLINGS (FOR EXPOSED SERVICE AND BURIED SERVICE ABOVE 54-INCH)**

- A. Sleeve type, flexible couplings shall be furnished and installed where shown on the Drawings or otherwise required to resist internal operating pressures. In addition to that specified herein, harnessed, sleeve type flexible couplings shall be provided on all exposed pipe 3 inches and larger in diameter that spans any expansion joint in a building or structure.

- B. Materials shall be of high strength steel and couplings shall be rated for the same pressures as the connecting piping.
- C. Gaskets shall be rubber. Bolts and nuts shall be alloy steel, corrosion-resistant and prime coated.
- D. Harnessing for exposed applications shall be by rodding across the sleeve type coupling to the nearest pipe joint on either side of the coupling using threaded rods and rod tabs unless otherwise approved by the Engineer.
- E. Couplings shall be as manufactured by Smith-Blair Model 411, Romac Industries Model 400, Dresser Industries Style 38, or equal as required and shown on the Drawings. All couplings shall be provided without interior pipe stop.
- F. Couplings shall be provided with manufacturer's fusion bonded epoxy painting system.

## **2.06 FLANGED COUPLING ADAPTERS**

- A. Flanged coupling adapters shall be furnished as required and as shown on the Drawings.
- B. Flanged coupling adapters shall be of ductile iron or carbon steel construction and shall be rated for the same pressure as the connected piping.
- C. All flanged coupling adapters shall be harnessed by tying the adapter to the nearest pipe joint flange using threaded rods and rod tabs unless otherwise approved by the Engineer.
- D. Flanged coupling adapters shall be manufactured by Smith-Blair Model 912 or 913, Romac Industries Model FCG or FC 400, Dresser Industries Model 128-W, or equal.
- E. Flanged coupling adapters shall be provided with manufacturer's fusion bonded epoxy painting system.

## **2.07 DISMANTLING JOINTS**

- A. Dismantling joints shall be furnished at locations shown on the Drawings.
- B. Dismantling joints for sizes less than 12-inch shall be of ductile iron or carbon steel construction and shall be rated for the same pressure as the connected piping. Dismantling joints for sizes greater than 12-inches shall be of carbon steel construction and shall be rated for the same pressure as the connected piping.
- C. Flanges for dismantling joints shall match the bolt pattern and pressure rating of the flanges for the connected piping.
- D. All dismantling joints shall be restrained utilizing restraining rods provided by the manufacturer. Restraining rods shall be constructed from ASTM A193 Grade B7 steel.

Restraining rods and restraint system shall be installed in strict accordance with manufacturer's recommendations.

- E. Dismantling joints shall be provided with manufacturer's fusion bonded epoxy painting system.
- F. Dismantling joints shall be manufactured by Smith Blair Model 975, Romac Industries Model DJ400, or equal.

## **2.08 GROOVED COUPLINGS**

- A. Grooved end pipe couplings shall be furnished as specified or shown on the Drawings.
- B. Materials shall be of malleable iron and couplings shall be rated for the same pressures as the connecting piping.
- C. Gaskets shall be rubber. Bolts and nuts shall be heat treated carbon steel track bolts and shall be plated.
- D. After installation, buried couplings shall receive two heavy coats of an approved coal tar which is compatible with the finish of the coupling. Exposed couplings shall be painted in accordance with Section 09 90 00 – Painting.
- E. Couplings shall be manufactured by Victaulic Company of America Style 31 or equal.

## **2.09 TAPPING SLEEVES AND TAPPING SADDLES**

- A. Tapping sleeves shall be similar to Mueller Outlet Seal, American Uniseal or Kennedy Square Seal. All sleeves shall have a minimum working pressure of 150 psi. All sleeves larger than twelve (12) inches shall be ductile iron. All taps shall be machine drilled; no burned taps will be allowed.
- B. Tapping saddles may be used on mains sixteen (16) inches and larger where the required tap size does not exceed one-half the size of the main (i.e. 8-inch tapping saddle for use on a 16-inch main). Tapping saddles shall be manufactured of ductile iron providing a factor of safety of at least 2.5 at a working pressure of 250 psi. Saddles shall be equipped with a standard AWWA C-110-77 flange connection on the branch. Sealing gaskets shall be "O" ring type, high quality molded rubber having an approximate seventy durometer hardness, placed into a groove on the curved surface of the tapping saddles. Straps shall be of alloy steel. The tapping saddle shall be the American tapping saddle, U.S. Pipe tapping saddle, or equal. All taps shall be machine cut, no burned taps will be allowed.

## **2.10 UNIONS**

- A. For ductile iron, carbon steel, and grey cast iron pipes assembled with threaded joints and malleable iron fittings, unions shall conform to ANSI B16.39.

- B. For copper piping, unions shall have ground joints and conform to ANSI B16.18.
- C. For PVC and CPVC piping, unions shall be socket weld type with Viton O-ring.

## **2.11 THERMOPLASTIC TUBING AND FITTINGS**

- A. Thermoplastic tubing shall be manufactured from polyallomer tubing. Tubing shall be protected from ultraviolet radiation degradation with a black coating or integral color conforming to ASTM D-1248, Type 1, Class C, Category 3. Fittings and connectors used with thermoplastic tubing shall be the flareless tube type constructed of brass conforming to SAE CA377, SAE CA360 or equal. Brass sleeves shall be used.
- B. Assembly of the thermoplastic tubing shall consist of pushing the tubing into the fitting and hand tightening the nut with final tightening with a wrench. Care shall be taken not to overtighten the nut. Plastic tube racks and bend holders shall be provided for holding the tubing in position. Needle valves used with thermoplastic tubing shall be the globe type constructed with a brass body, stem and seat and Buna-N "O"-ring seals. Installation shall be in accordance with the manufacturer's recommendations. Thermoplastic tubing, shall be the Impolene (polyallomer) system and needle valves, fittings and connectors shall be the Poly-Flo with 261 UB Universal Nut and Sleeve system as manufactured by Imperial Eastman, or equal.

## **2.12 HEAT TRACED PIPING**

- A. Exposed pipes to be insulated shall also be protected from freezing by heat tracing. Freeze protection heat tracing shall consist of twin 16 AWG copper brass wires with a semiconductor polymer core where electrical resistance varies with temperature. The heat tracing shall have a fluoropolymer outer jacket for corrosion resistance. The heat tracing shall be rated for three (3) watts per foot output, self-regulating with a maximum temperature of 150°F, equal to a Chromalox No. SRL3-1CT383400. Maximum length for tape shall be 300 feet for each circuit. Temperature controller shall be provided to sense pipe temperature to determine on or off condition of the heat tracing. Temperature control shall be equal to a Chromalox No. RTBC-2-384729. The heat tracing system shall operate on 120 VAC. See Drawings for installation detail. Heat tracing of piping shall be provided as specified in Section 40 06 20 – Schedules.

## **2.13 FLEXIBLE RESTRAINED EXPANSION JOINTS**

- A. Restrained expansion joints shall be manufactured of 60-42-10 ductile iron conforming to material and other applicable requirements of ANSI/AWWA C153/A21.53.
- B. Each pressure containing component shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the materials requirements of, and tested in accordance with, ANSI/AWWA C213 and shall meet or exceed the requirements of ANSI/AWWA C550.
- C. Seals shall conform to the applicable requirements of ANSI/AWWA C111/A21.11.

- D. All bolts used in the assemblies shall be stainless steel and shall be coated with a premium quality epoxy.
- E. Flanged ends shall comply with ANSI/AWWA C110/A21.10, with the addition of O-ring groove and O-ring.
- F. Mechanical joint ends shall comply with ANSI/AWWA C153/A21.53.
- G. Restrained expansion joints shall have a minimum pressure rating of 350 psi with a minimum safety factor of 3:1. Each assembly shall be tested at 350 psi before shipment.
- H. Restrained expansion joints shall provide for self-restraint without tie rods and shall provide for expansion and contraction capabilities cast as an integral part of the end connection.
- I. Flexible restrained expansion joints shall allow for 8-inches (+6"-2") minimum expansion.
- J. Flexible restrained expansion joints shall consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint having a minimum of 15□ deflection per ball.
- K. Restrained expansion joints shall be the Single Ball or Double Ball FLEX-TEND Expansion Joint as manufactured by EBAA Iron Inc., or equal.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. All piping shall be installed by skilled workmen and in accordance with the best standard practice for piping installation as shown on the Drawings, specified or recommended by the pipe manufacturer. Proper tools and appliances for the safe and convenient handling and installing of the pipe and fittings shall be used. Great care shall be taken to prevent any pipe coating from being damaged on the inside or outside of the pipe and fittings. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be cracked, damaged, or otherwise defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced with a sound one in a satisfactory manner by the Contractor and at his own expense. Pipe and fittings shall be thoroughly cleaned before they are installed and shall be kept clean until they are accepted in the complete work. All piping connections to equipment shall be provided with unions or coupling flanges located so that piping may be readily dismantled from the equipment. At certain applications, Dresser, Victaulic, or equal, couplings may also be used. All piping shall be installed in such a manner that it will be free to expand and contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and

horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Unless otherwise shown or approved, provided a minimum headroom clearance under all piping of 7 feet 6 inches.

- B. Unless otherwise shown or specified, all waste and vent piping shall pitch uniformly at a 1/4-inch per foot grade and accessible cleanouts shall be furnished and installed as shown and as required by local building codes. Installed length of waste and vent piping shall be determined from field measurements in lieu of the Drawings.
- C. All excavation shall be made in such a manner and to such widths as will provide ample room for properly installing the pipe and permit thorough compaction of backfill around the pipe. The minimum trench widths shall be in strict accordance with the "Trench Width Excavation Limits" as shown on the Drawings. All excavation and trenching shall be done in strict accordance with these specifications and all applicable parts of the OSHA Regulations, 29CFR 1926, Subpart P.
- D. ALL EXCAVATION REQUIRED BY THIS CONTRACT SHALL BE UNCLASSIFIED. NO ADDITIONAL PAYMENT WILL BE MADE FOR ROCK EXCAVATION REQUIRED FOR THE INSTALLATION OF PIPE OR STRUCTURES SHOWN ON THE DRAWINGS.
- E. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.
- F. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, or obstructions.
- G. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet. The Contractor shall excavate the trenches to the full depth, width and grade indicated on the Drawings including the relevant requirements for bedding. The trench bottoms shall then be examined by the Engineer as to the condition and bearing value before any pipe is laid or bedding is placed.
- H. No pressure testing shall be performed until the pipe has been properly backfilled in place. All pipe passing through walls and/or floors shall be provided with wall pipes or sleeves in accordance with the specifications and the details shown on the Drawings. All wall pipes shall be of ductile iron and shall have a water stop located in the center of the wall. Each wall pipe shall be of the same class, thickness, and interior coating as the piping to which it is joined. All buried wall pipes shall have a coal tar outside coating on exposed surfaces.

- I. JOINT DEFLECTION SHALL NOT EXCEED 75 PERCENT OF THE MANUFACTURERS RECOMMENDED DEFLECTION. Excavation and backfilling shall conform to the requirements of Section 31 00 01 – Earthwork, and as specified herein. Maximum trench widths shall conform to the Trench Width Excavation Limits shown on the Drawings. All exposed, submerged, and buried piping shall be adequately supported and braced by means of hangers, concrete piers, pipe supports, or otherwise as may be required by the location.
- J. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. UNDER NO CIRCUMSTANCES SHALL ANY OF THE MATERIALS BE DROPPED OR DUMPED INTO THE TRENCH.
- K. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fitting, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.
- L. All piping shall be installed in such a manner that it will be free to expand and/or contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Pipes crossing within a vertical distance of less than or equal to one (1) foot shall be encased and supported with concrete at the point of crossing to prevent damage to the adjacent pipes as shown on the Drawings.
- M. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation; and no pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at his own expense. Pipe shall not be laid in water or when trench conditions are unsuitable for work.
- N. Proper and suitable tools and appliances for the safe convenient handling and laying of pipe shall be used and shall in general agree with manufacturer's recommendations.
- O. AT THE CLOSE OF EACH WORK DAY, THE END OF THE PIPELINE SHALL BE TIGHTLY SEALED WITH A CAP OR PLUG SO THAT NO WATER, DIRT, OR OTHER FOREIGN SUBSTANCE MAY ENTER THE PIPELINE, AND THIS PLUG SHALL BE KEPT IN PLACE UNTIL PIPE LAYING IS RESUMED.



- P. During the laying of pipe, each pipe manufacturer shall provide his own supervisor to instruct the Contractor's pipe laying personnel in the correct procedure to be followed.
- Q. Ordinarily only full lengths of pipe (as furnished by the pipe manufacturer) shall be used exceptions: closure pieces at manholes and areas where joint deflection is required.
- R. For gravity sewer installations, the Contractor shall use a laser device to maintain the trench and pipe alignment. The laser device shall be re-checked for correct elevation and pipe alignment prior to pipe installation if the device is left in the pipe overnight. Corrected invert elevations at each manhole and any adjustments will be coordinated and approved by the Engineer.
- S. ALL PIPING SHALL HAVE TYPE "A" BEDDING AS SHOWN ON THE DRAWINGS, UNLESS OTHERWISE SPECIFIED HEREIN OR INDICATED ON THE DRAWINGS.

### **3.02 CARBON AND STAINLESS STEEL PIPE**

- A. Installation of steel pipe shall be by skilled workmen and shall conform to the applicable sections of AWWA Manual M-11. Joints for steel piping shall be either screwed, welded, or flanged as shown on the Drawings or as specified.
- B. Welding in the field shall be performed only when requested on the shop drawings and permitted by the Engineer for carbon steel pipe. No welding of stainless steel pipe shall be allowed in the field. All field welds shall be radiographically inspected.
- C. Installation of the steel casing pipe shall be by skilled workmen and in accordance with the best standard practice for steel pipe installation. Joints for steel casing pipe shall be butt welded.
  - 1. The boring equipment to be used for installing the jacked casing shall be of such size and capacity to allow the boring to proceed in a safe and expeditious manner. The installation of the casing and boring of the hole shall be done simultaneously to avoid cave-ins or settlement and for safety of traffic above.
  - 2. The Contractor shall check the vertical and horizontal alignment of the casing by survey instrument at least once during each four feet of advance, or as directed by the Engineer. Pits shall be well sheeted and braced as necessary for safe and adequate access for workmen, inspectors and materials and shall be of a size suitable to equipment and material handling requirements.
  - 3. Under no conditions shall jetting or wet boring of encasement under pavement be allowed.
  - 4. After installation of the carrier pipe, each end of the casing pipe shall be made watertight with a brick masonry bulkhead. In addition, a Class B concrete cradle shall be provided from each end of the bulkhead to the first pipe joint outside of the bulkhead.

### 3.03 JOINTS IN PIPING

- A. Restrained joints shall be provided on all pipe joints as specified herein and shown on the Drawings. Restrained joints shall be made up similar to that for push-on joints.
- B. Push-on joints include a single rubber gasket which fits into the bell end of the pipe. The gasket shall be wiped clean, flexed and then placed in the socket. Any bulges in the gasket which might interfere with the entry of the plain end of the pipe shall be removed. A thin film of lubricant shall be applied to the gasket surface which will come into contact with the spigot end of the pipe. The lubricant shall be furnished by the pipe manufacturer. The plain end of the pipe, which is tapered for ease of assembly, shall be wiped clean and a thick film of lubricant applied to the outside. The pipe shall be aligned and carefully entered into the socket until it just makes contact with the gasket. The joint assembly shall be completed by entering the pipe past the gasket until it makes contact with the bottom of the socket. The pipe shall be pulled "home" with an approved jack assembly as recommended by the pipe manufacturer. If assembly is not accomplished by reasonable force, the plain end shall be removed, and the condition corrected.
- C. Flanged joints shall be brought to exact alignment and all gaskets and bolts or studs inserted in their proper places. Bolts or studs shall be uniformly tightened around the joints. Where stud bolts are used, the bolts shall be uniformly centered in the connections and equal pressure applied to each nut on the stud. Pipes in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot.
- D. Mechanical joints shall be made up with gaskets, glands and bolts. When a joint is to be made up, the bell or socket and plain end shall be cleaned and washed with a solution of mild soap in water; the gland and gasket shall be slid onto the plain end and the end then entered into the socket until it is fully "home" on the centering ring. The gasket shall then be painted with soapy water and slid into position, followed by the gland. All bolts shall be inserted and made up hand tight and then tightened alternately to bring the gland into position evenly. Excessive tightening of the bolts shall be avoided. All nuts shall be pulled up using a torque wrench which will not permit unequal stresses in the bolts. Torque shall not exceed the recommendations of the manufacturer of the pipe and bolts for the various sizes. Care shall be taken to assure that the pipe remains fully "home" while the joint is being made. Joints shall conform to the applicable AWWA Specifications.
- E. Threaded and/or screwed joints shall have long tapered full depth threads to be made with the appropriate paste or jointing compound, depending on the type of fluid to be processed through the pipe. All pipe up to, and including 1-1/2-inches, shall be reamed to remove burr and stood on end and well pounded to remove scale and dirt. Wrenches on valves and fittings shall be applied directly over the joint being tightened. Not more than three pipe threads shall be exposed at each connection. Pipe, in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot. Joints in all piping used for chlorine gas lines shall be made up with

a glycerine and litharge cement. Joints in plastic piping (PVC/CPVC) shall be laid and joints made with compounds recommended by the manufacturer. Installation shall conform to the requirements of ASTM D2774 and ASTM D2855. Unions required adjacent to valves and equipment.

- F. Soldered joints shall have the burrs removed and both the outside of pipe and the inside of fittings shall be thoroughly cleaned by proper tools recommended for that purpose. Flux shall be applied to both pipe and inside of fittings and the pipe placed into fittings and rotated to insure equal distribution of flux. Joints shall be heated and solder applied until it shows uniformly around the end of joints between fitting and pipe. All joints shall be allowed to self-cool to prevent the chilling of solder. Combination flux and solder paste manufactured by a reputable manufacturer is acceptable. Unions required adjacent to valves and equipment.
- G. Welded joints shall be made by competent operators in a first class workmanlike manner, in complete accordance with ANSI B31.1 and AWWA C206. Welding electrodes shall conform to ASTM A233, and welding rod shall conform to ASTM A251. Only skilled welders capable of meeting the qualification tests for the type of welding which they are performing shall be employed. Tests, if so required, shall be made at the expense of the Contractor, if so ordered by the Engineer. Unions shall be required adjacent to valves and equipment.
- H. Copper joints shall be thoroughly cleaned and the end of pipes uniformly flared by a suitable tool to the bevels of the fittings used. Wrenches shall be applied to the bodies of fittings where the joint is being made and in no case to a joint previously made. Dimensions of tubing and copper piping shall be in complete accordance with the fittings used. No flare joints shall be made on piping not suited for flare joints. Installations for propane gas shall be in accordance with NFPA 54 and/or 58.
- I. Solvent or adhesive welded joints in plastic piping shall be accomplished in strict accordance with the pipe manufacturer's recommendations, including necessary field cuttings, sanding of pipe ends, joint support during setting period, etc. Care shall be taken that no droppings or deposits of adhesive or material remain inside the assembled piping. Solvent or adhesive material shall be compatible with the pipe itself, being a product approved by the pipe manufacturer. Unions are required adjacent to valves and equipment. Sleeve-type expansion joints shall be supplied in exposed piping to permit 1-inch minimum of expansion per 100 feet of pipe length.
- J. Dielectric isolation such as flange isolation kits, dielectric unions, or similar, shall be installed wherever dissimilar metals are connected according to the following table.

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			•	•	•	•	•	•	•
Galvanized Steel			•	•	•	•	•	•	•
Aluminum	•	•		•	•	•	•	•	•
Cast Iron	•	•	•				•	•	•
Ductile Iron	•	•	•				•	•	•
Mild Steel/ Carbon Steel	•	•	•				•	•	•
Copper	•	•	•	•	•	•			•
Brass	•	•	•	•	•	•			•
Stainless Steel	•	•	•	•	•	•	•	•	

Notes:

• signifies dielectric isolation is required between the two materials noted.

Consult Engineer for items not listed in table.

Provide flange isolation kits for all flanged connections of dissimilar metals and hardware including connections to equipment.

Contractor shall include all isolation descriptions with piping submittals.

- K. Eccentric reducers shall be installed where air or water pockets would otherwise occur in mains because of a reduction in pipe size.
- L. Joints in polypropylene and polyvinylidene fluoride pipe shall be butt fusion weld. All butt welding shall follow the requirements of ASTM D-2657 and the manufacturer's recommendations.

### 3.04 FLUSHING AND TESTING

- A. All piping shall be properly flushed and tested unless specifically exempted elsewhere in the Specifications or otherwise approved by the Engineer. Air and gas pipelines shall be flushed and tested with compressed air. Gravity sewer piping shall be flushed and tested as specified in Section 33 05 61 – Utility Structures. All other liquid conveying pipelines shall be flushed and tested with water. The Contractor shall furnish and install all means and apparatus necessary for getting the air or water into the pipeline for flushing and testing including pumps, compressors, gauges, and meters, any necessary plugs and caps, and any required blow-off piping and fittings, etc., complete with any necessary reaction blocking to prevent pipe movement during the flushing and testing. All pipelines shall be flushed and tested in such lengths or sections as agreed upon among the

Owner, Engineer, and Contractor. Test pressures shall be as specified in Section 40 06 20 – Schedules and shall be measured at the lowest point of the pipe segment being tested. The Contractor shall give the Owner and Engineer reasonable notice of the time when he intends to test portions of the pipelines. The Engineer reserves the right, within reason, to request flushing and testing of any section or portion of a pipeline.

- B. The Contractor shall provide water for all flushing and testing of liquid conveying pipelines. Raw water or non-potable water may be used for flushing and testing liquid pipelines not connected to the potable water system. Only potable water shall be used for flushing and testing the potable water system.
- C. Air and gas piping shall be completely and thoroughly cleaned of all foreign matter, scale, and dirt prior to start-up of the air or gas system.
- D. At the conclusion of the installation work, the Contractor shall thoroughly clean all new liquid conveying pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, etc., which may have entered the pipe during the construction period. If after this cleaning any obstructions remain, they shall be corrected by the Contractor, at his own expense, to the satisfaction of the Engineer. Liquid conveying pipelines shall be flushed at the rate of at least 2.5 feet per second for a duration suitable to the Engineer or shall be flushed by other methods approved by the Engineer.
- E. Compressed/service air and gas piping shall be flushed by removing end caps from the distribution lines and operating one (1) compressor, in accordance with the manufacturer's instructions.
- F. After flushing, all air piping shall be pressure and leak tested prior to coating and wrapping of welded joints. Immediately upon successful completion of the pressure and leak test, welded joints shall be thoroughly cleaned of all foreign matter, scale, rust, and discoloration and coated in accordance with the Specifications.
- G. All process air piping shall be leak tested by applying a soap solution to each joint. Leak tests shall be conducted with one (1) blower in service at normal operating pressure.
- H. During testing the piping shall show no leakage. Any leaks or defective piping disclosed by the leakage test shall be repaired or replaced by the Contractor, at his own expense, and the test repeated until all such piping shows tight.
- I. All buried process air piping shall be pressurized to 25 psig and tested for leaks by applying a soap solution to each joint. The air supply shall be stopped and the pipe pressure monitored. System pressure shall not fall by more than 0.5% of the 25 psig test pressure over a one-hour test period. Should the system fail to hold the required pressure for one hour, the cause shall be determined and corrected and the test repeated until a successful test of the entire system is obtained.
- J. Field leakage tests shall be performed for all submerged process air piping. The procedure shall consist of operating the system under clear nonpotable water for visual

identification of all leaks. All field leakage tests shall be witnessed by the Engineer. All submerged piping shall be installed free of any leaks.

- K. After flushing, all liquid conveying pipelines shall be hydrostatically tested at the test pressure specified in the appropriate Piping System Schedule in Section 40 06 20 – Schedules. The procedure used for the hydrostatic test shall be in accordance with the requirements of AWWA C600. Each pipeline shall be filled with water for a period of no less than 24 hours and then subjected to the specified test pressure for 2 hours. During this test, exposed piping shall show no leakage. Allowable leakage in buried piping shall be in accordance with AWWA C600.
- L. Any leaks or defective pipe disclosed by the hydrostatic test shall be repaired or replaced by the Contractor, at his own expense, and the test repeated until all such piping shows tight.
- M. After flushing, all gas piping shall be leak tested in accordance with all local codes and regulations and in conformance with the recommendations or requirements of any National Institute or Association for the specific service application.

### **3.05 DISINFECTION**

- A. All pipe and fitting connected to and forming a part of a potable water supply shall be disinfected in accordance with the procedures described in AWWA C 651. Disinfection shall also be in accordance with the requirements of the AWWA C651 and the Owner.
- B. Disinfection shall be accomplished after the pipe has been flushed, if applicable, and passed the hydrostatic test. Such piping shall be filled with 50 parts per million (PPM) of chlorine and held in contact for not less than 24 hours. Final tests after 24 hours contact time shall show a minimum residual chlorine content of 10 ppm in all parts of the system. Disinfection shall be repeated as often as necessary, and as directed by the Engineer and/or the Owner until the minimum residual chlorine content of 10 ppm has been reached. The Contractor shall obtain certificates of satisfactory bacteriological tests and furnish them to the Owner before the request is made for acceptance of the work. The Contractor shall furnish and install, at his own expense, all means and apparatus necessary for performing the disinfection. The chlorine solution shall be thoroughly flushed out prior to placing the new sections of pipe in service. The Contractor is cautioned that the spent chlorine solution must be disposed of in such a way as not to be detrimental to animal, plant, or fish life. Chlorine residual tests will be made after flushing to assure that residual is not in excess of 1 ppm at any point in system.

### **3.06 PAINTING AND COLOR-CODING SYSTEM**

- A. All exposed piping specified shall be color coded in accordance with the Owner's standard color designation system for pipe recognition. In the absence of a standard color designation system, the Engineer will establish a standard color designation for each piping service category from color charts submitted by the Contractor in compliance with Section 09 90 00 – Painting.

B. All piping specified in this Section shall be painted in accordance with Section 09 90 00 – Painting, except as follows:

1. Copper pipe
2. Stainless steel pipe. Flanges and supports or hangers shall be painted.

**END OF SECTION**

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**SECTION 40 05 17**  
**COPPER PIPE**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

**PART 2 – PRODUCTS**

**2.01 TYPE L COPPER PIPE AND FITTINGS**

- A. Type L copper piping shall be seamless, hard drawn and shall conform to ASTM B 88. Solder fittings shall be wrought copper conforming to ANSI B.16.22 or cast brass conforming to ANSI B.16.18 95/5. All exposed copper pipe and fittings shall be Type L.

**2.02 TYPE K COPPER PIPE AND FITTINGS**

- A. Type K copper piping shall be seamless, soft temper and shall conform to ASTM B 88. Fittings used with this pipe shall be flare or compression type fittings as manufactured by Swagelok, or equal, and shall conform to ANSI B16.26. All buried copper pipe and fittings shall be Type K.

**2.03 SOLDER**

- A. Solder shall consist of 95 percent tin and 5 percent antimony. Silver solder shall consist of 15 percent silver, 80 percent copper, and 5 percent phosphorous in accordance with ASTM B260-62T. Soldering shall be in conformance with Section 3 of the C.A.B.R.A. Copper Tube Handbook.

**2.04 SOFT COPPER TUBING**

- A. Soft copper tubing in all sizes, shall conform to the appropriate ASTM Specifications; and fittings used with this tubing shall be compression or flare type, as manufactured by Swagelock, or equal.

**PART 3 – EXECUTION**

**3.01 INSTALLATION**

- A. Installation of copper pipe shall be by skilled workman in accordance with the manufacturer's recommendations. Use teflon tape at all fittings unless otherwise

required for intended service. Install unions at the connections to each piece of equipment to allow removal of equipment without dismantling connecting piping.

- B. Wall sleeves shall be provided for all piping passing through exterior walls and shall be of the same material as the piping to which it is joined. All wall sleeves shall be provided with an acceptable waterstop.
- C. The Contractor shall provide hot and cold water mains with branches and risers complete from point indicated on the Drawings running to all fixtures and other outlets indicated. Mains and branches shall be run generally as shown on the Drawings. The Contractor shall provide all interior water piping, branches, and risers as shown on the Drawing and shall make connections to all plumbing fixtures, hose bibs, wall hydrants, and other points requiring water under this and other Divisions of the Specifications.
- D. All water mains and branches shall be pitched at least one (1) inch in twenty-five (25) feet toward fixtures. The piping installation shall be arranged so that the entire system can be drained through fixture supply connections.
- E. Unions shall be installed at the connections to each piece of equipment to allow for removal of equipment without dismantling connecting piping.
- F. Joints 1-1/4 inches and larger shall be made with silver solder. For joints less than 1-1/4 inches and all valves (regardless of size) use 95/5 solder. Soldered joints shall be prepared with a non-corrosive paste flux in accordance with manufacturer's instructions. All joints shall be thoroughly cleaned with emery cloth and reamed out before assembly. Acid core solder will not be permitted.

**END OF SECTION**

**SECTION 40 05 19**  
**DUCTILE IRON PIPE**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. All ductile iron pipe and specials shall be marked with the manufacturer's name or trademark, size, weight, thickness class, the date of manufacture, and the word "Ductile".
- B. Ductile iron pipe (DIP) of the sizes shown or specified shall conform to ANSI A21.51 (AWWA C151), Grade 60-42-10 for ductile iron pipe centrifugally cast in metal molds or sand-lined molds. All ductile iron pipe shall conform to ANSI A21.50 (AWWA C150) for thickness design and shall be supplied in 18 or 20 foot nominal lengths or as required to meet the requirements of the Drawings. Fittings and specials shall be cast iron or ductile iron, conforming to the requirements of ANSI A21.10 (AWWA C110) or ANSI A21.53 (AWWA C153).
- C. Minimum Class 53 pipe shall be used for flanged spools.
- D. Reference Section 40 05 00 – Basic Mechanical Requirements

**PART 2 – PRODUCT**

**2.01 DUCTILE IRON PIPE AND FITTINGS**

- A. All pipe and fittings shall be lined with PROTECTO 401 ceramic epoxy with a minimum thickness of 40 mils nominal dry film.
- B. All buried DIP and fittings shall have a bituminous coating on the exterior surfaces in accordance with ANSI A21.51 (AWWA C151). All exposed DIP and fittings shall have a shop applied prime coat in accordance with Section 09 90 00 – Painting.
- C. Requirements for various types of joints are described in the following paragraphs.  
**UNLESS OTHERWISE NOTED HEREIN OR ON THE DRAWINGS, ALL EXPOSED DUCTILE IRON PIPING SHALL HAVE FLANGED JOINTS.**
- D. Flanged joints and fittings shall have a minimum pressure rating of 250 psi with 125 lb. American Standard flanges. All flanges and fittings shall conform to the requirements of ANSI B16.1. Flanges shall be ductile iron and shall be of the threaded or screw on type. The face of the flanges shall be machined after installation of the flange to the pipe. No raised surface shall be allowed on flanges. Flanged pipe shall conform to the requirements of ANSI Specification A21.15, (AWWA C115). Pipe lengths shall be fabricated to meet the requirements of the Drawings.

- E. Gaskets shall be the "Ring Gasket" type, 1/8-inch minimum thickness, cloth inserted rubber, red rubber or neoprene and shall be suitable for the service intended. Gaskets for glass lined pipe shall be TORUSEAL flange gasket, or equal. Bolts shall be of the size and length called for and in accordance with the "American Standard" and comply with the requirements of the ANSI/AWWA Standards. The bolts for flanged joints shall be a minimum ASTM A307; Grade B carbon steel and be in accordance with ANSI A21.10, (AWWA C110). The bolts shall have hexagonal heads and nuts, no washers shall be used.
- F. Bell and spigot pipe shall be provided with push on, O-ring rubber gasket, compression type joints and shall conform to the requirements of ANSI A21.11 (AWWA C111). Fittings and specials shall be supplied with mechanical joints as specified for mechanical joint pipe. If required by installation conditions, pipe shall have cast-on lugs for adequately tying it together.
- G. Mechanical joints and fittings shall conform to the requirements of ANSI A21.11, (AWWA C111). Joints shall be made employing a tapered rubber gasket forced into a tapered groove with a ductile iron follower ring. If required by installation conditions, pipe and fittings shall have cast-on lugs for adequately tying the pipe and fittings together. These shall be in conformance with standard practice and as outlined under the appropriate AWWA Specifications.
- H. Bolts for mechanical joints shall be high strength corrosion resistant low-alloy steel tee-head bolts with hexagonal nuts.
- I. Mechanical coupling joint pipe and fittings shall be split type, shouldered end. Coupling materials shall be malleable iron. Couplings shall have a minimum pressure rating and service equal to that of the connected piping. Gaskets shall be of rubber. Bolts and nuts shall be heat treated carbon steel track bolts and shall be plated. After installation, buried couplings shall receive two heavy coats of coal tar epoxy (min. 24 mil thickness) which is compatible with the finish of the couplings. Couplings shall be as manufactured by Victaulic Company of America Style 31, or equal.
- J. Restrained joint pipe shall consist of factory manufactured bolted retainer rings, ductile iron locking segments held in place by rubber retainers, or ductile iron retaining rings that lock over the bell of the joint and are secured to prevent rotation, and factory welded retainer beads or rings on the spigot of the pipe. All components of the bolted or snap ring assemblies shall be constructed of corrosion-resistant, high strength, low-alloy steel. Restrained joint pipe shall be Flex-Ring or Lock-Ring type joints as manufactured by American Cast Iron Pipe Company, HP LOK or TR Flex as manufactured by US Pipe, Bolt-Lok or Snap-Lok as manufactured by Griffin Pipe Products, TR Flex or Super Lock as manufactured by Clow Water Systems Co., or approved equal.
- K. Restrained fittings for pipe systems 14-inches in diameter and smaller shall be Mechanical Joint fittings with restraint assemblies such as Stargrip by Star Pipe Systems, Mega Lug by EBAA Iron, ONE LOK by Sigma, Grip Ring by Romac, or

approved equal. Where threaded-rods are allowed, the rods and tabs shall be designed for the specified restraint system design pressure, shall have lengths less than 10 feet between fittings, and shall be painted with two heavy coats of coal tar epoxy after installation.

- L. The manufactured systems for thrust restraint indicated above shall be used where restrained joint ductile iron pipe and fittings are specified or indicated on the drawings. Gripping gaskets are not an acceptable form of restraint. Thrust restraint and harnessing systems such as threaded-rods, friction clamps, retainer glands shall be used only where specifically specified herein, indicated on the drawings or if allowed by the Engineer in isolated applications where conditions warrant and necessitate their use. Concrete thrust blocks may be used in accordance with the schedule indicated on the drawings, if applicable.
- M. Cast Iron Soil Pipe shall conform to the standards of the Cast Iron Soil Pipe Institute (CISPI) Specification HS-67, and also ANSI Specification A-112.5.2 for Hub & Spigot pipe or A.112.5.1 for Hub & Spigot pipe or A.112.5.1 for No-Hub Pipe. Pipe class shall be "Extra Heavy:(XH).

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**SECTION 40 05 31**  
**PVC/CPVC PIPE**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

**PART 2 – PRODUCTS**

**2.01 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS**

- A. Dumpster Pad and Valve Vault drain piping:
1. PVC pipe and fittings shall be manufactured in accordance with ASTM D 1785, D 1784 and F 441, "normal impact" pipe, Schedule 40 or 80 as specified.
  2. Fittings used with this pipe shall be socket type or flanged type as specified herein or indicated on the Drawings. Plastic piping shall be installed in full accordance with the manufacturer's recommendations for the specific installation. No field bending or distortion of the pipe will be permitted.
  3. PVC pipe shall be Type 1 Grade 1 conforming to ASTM D 1784 and D 1785. Fittings shall conform to the following standard specifications:
    - a. Socket Type: (Schedule 40); ASTM D 2466
    - b. Socket Type: (Schedule 80); ASTM D 2467
  4. Solvent cement for socket type joints shall conform to ASTM D 2564 for PVC pipe and fittings. Solvent cement for chemical service shall be Weld-On 724 as manufactured by IPS Corporation, or equal.
- B. Gravity Sewer piping:
1. Type PSM polyvinyl chloride (PVC) pipe and fittings shall conform to the requirements of ASTM D 3034 with a maximum SDR of 26. Pipe and fittings shall have bell and spigot ends with O-ring rubber gasketed, compression type joints. Joints shall conform to the requirements of ASTM Specification D 3212. Reruns of reclaimed materials shall not be accepted.
  2. Large diameter polyvinyl chloride (PVC) pipe and fittings shall conform to the requirements of ASTM F 679 with a minimum pipe stiffness of 115. Pipe and fittings shall have bell and spigot ends with O-ring rubber gasketed, compression

type joints. Joints shall conform to the requirements of ASTM Specification D 3212. Reruns of reclaimed materials shall not be accepted.

**2.02 REINFORCED THERMOPLASTIC HOSE AND FITTINGS**

- A. Reinforced thermoplastic hose shall be clear type, reinforced with polyester yarn. Hose material shall be PVC, EVA (Ethyl Vinyl Acetate), or Low-Density Polyethylene, depending on the application, as indicated in the Drawings. Hose shall be rated for the following working pressures:

Internal Diameter	Minimum Working Pressure (at 68°F)
½"	200 psi (75 psi at 150°F)
1"	125 psi (50 psi at 150°F)
1-½"	100 psi
2"	75 psi

- B. Hoses shall be continuous from the source to the discharge unless shown otherwise on the drawings. Splices shall not be allowed unless approved in writing by the Engineer. If allowed, splices shall occur only in handholes or manholes. Connections and splices, if allowed, shall be barb and clamp type using materials that are compatible with the chemical being conveyed.

Internal Diameter	Minimum Continuous Length
½"	1000 feet
1"	1000 feet
1-½"	800 feet
2"	500 feet

- C. Reinforced thermoplastic hose shall be a manufactured product of Parker Nexgen or equal.
- D. Wetted materials shall be completely resistant to corrosion by the specified chemicals. Hose manufacturer shall guarantee that the hose is suitable for the intended service.



## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) and High Density Polyethylene (HDPE) pipe shall be laid and joints assembled according to the respective manufacturer's recommendation. PVC pipe installation shall comply with applicable sections of the Uni-Bell PVC Pipe Association Recommended Standard Specifications.
- B. Plastic piping shall not be installed when the temperature is less than 60 degrees F except as otherwise recommended by the manufacturer and approved by the Engineer.

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**SECTION 40 05 51**  
**VALVES, GENERAL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install, complete with all assemblies and accessories, all valves shown on the Drawings and specified herein including all fittings, appurtenances and transition pieces required for a complete and operable installation.
- B. All valves shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. Except where noted otherwise, valves designated for water service shall conform to pertinent sections of the latest revision of AWWA C500 Specifications. Cast iron valve bodies and parts shall meet the requirements of the latest revision of ASTM Designation A-126, "Standard Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B."
- C. All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.
- D. Valves shall have flanged ends for exposed service and mechanical joint ends for buried service, unless otherwise shown on the Drawings or specified herein. Flanged ends shall be flat-faced, 125 lb. American Standard unless otherwise shown or specified in accordance with ANSI B16.1. All bolt heads and nuts shall be hexagonal of American Standard size. The Contractor shall be responsible for coordinating connecting piping. Valves with screwed ends shall be made tight with Teflon tape. Unions are required at all screwed joint valves.

**1.02 SUBMITTALS**

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures; and Section 46 00 00 – Equipment General Provisions:
  - 1. Performance tests shall be conducted in accordance with the latest revision of AWWA C500.
  - 2. Shop Drawings conforming to the requirements of Section 01 33 00 – Submittal Procedures, are required for all valves, and accessories. Submittals shall include all layout dimensions, size and materials of construction for all components, information on support and anchoring where necessary, pneumatic and hydraulic characteristics and complete descriptive information to demonstrate full compliance with the Documents. Shop Drawings for electrically

operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the electrical power supply and remote status and alarm indicating devices. Electrical control schematic diagrams shall be submitted with the Shop Drawings for all electrical controls. Diagrams shall be drawn using a ladder-type format in accordance with JIC standards. Shop Drawings for pneumatically operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the compressed air (service air) system and electrical controls.

3. Operation and maintenance manuals and installation instructions shall be submitted for all valves and accessories in accordance with the Specifications. The manufacturer(s) shall delete all information which does not apply to the equipment being furnished.

### 1.03 CONTRACTOR'S RESPONSIBILITIES

- A. The Contractor shall provide the services of a qualified representative of the manufacturer(s) of the equipment named below to check out and certify the installation(s), to supervise the initial operation, and to instruct the Owner's operating personnel in proper operation and maintenance procedures in accordance with the following schedule:

Item	Valve/Operator Type	Minimum On-Site Time Requirements
1	Automatic Control Check Valve	One (1) 8-hour day
2	Surge Anticipators	One (1) 8-hour day
3	Motor Operated Modulating Valves	One (1) 8-hour day
4	Motor Operated Open-Close Valves (required only if manufacturer is other than for Item 3 above)	One (1) 8-hour day
5	Pneumatic Hydraulic Cylinder Operated Valves	One (1) 8-hour day

- B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.
- C. A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies notes.
- D. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

## **PART 2 – PRODUCTS**

### **2.01 FLOW INDICATORS**

- A. Flow indicators shall be the Akron ball-type as manufactured by Brooks Instrument Co., Fischer and Porter, or equal, and shall have bronze bodies, glass dome, and plastic ball.

### **2.02 CORPORATION STOPS**

- A. Corporation stops shall be of bronze with tapered male iron pipe threads on inlets and outlets. Terminal outlets shall have screwed bronze hex head dust plugs or caps. Unions shall be used on all corporation stop outlets with connecting piping. Corporation stops shall have a minimum working pressure rating of 250 psi and shall be as manufactured by Mueller Co., Hays Mfg. Div. of Zurn Industries, or equal.

### **2.03 FLOOR BOXES**

- A. Floor boxes shall be provided for all nut operated or floor accessed valves. Floor boxes shall be of the adjustable, sliding type, cast iron, suitable to withstand heavy traffic, as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., or equal. The covers shall be marked with appropriate designations of piping contents (i.e.: water, sewer) and bases shall be the round type. All nut operated valves in this Section shall be clearly identified by stainless steel or laminated plastic identification tags. The tags shall be permanently affixed to the inside of the floor boxes, under grating, etc. and shall bear the embossed letters which clearly identify each valve by its appropriate designation.
- B. Two (2) valve operating wrenches shall be supplied in 4-foot lengths with tee handles for each size nut supplied. Valve wrenches shall be Model No. F-2520 as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., Figure No. 122, or equal.

### **2.04 VALVE BOXES**

- A. The Contractor shall furnish and install valve boxes as shown on the Drawings and specified herein.
- B. All valve boxes shall be placed so as not to transmit shock or stress to the valve and shall be centered and plumb over the operating nut of the valve. The ground in the trench upon which the valve boxes rest shall be thoroughly compacted to prevent settlement. The boxes shall be fitted together securely and set so that the cover is flush with the finished grade of the adjacent surface. A concrete pad as detailed on the Drawings shall be provided around the valve box, sloped outwards.
- C. All valve boxes shall be 2-piece cast iron, sliding type, 5-1/4" shaft, with heavy duty traffic weight collar and the lid marked with the appropriate carrier product (i.e.: WATER). Boxes shall be as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., Charlotte Pipe and Foundry Company, or equal.

## 2.05 STRAINERS

- A. Y-Strainers shall be Y-pattern cast iron body, flanged or screwed ends with stainless steel or Monel, 20 mesh strainers. Strainers shall be 200 psi, cold-water service strainers, as manufactured by WATTS, Crane Co., Zurn, or equal.
- B. Caustic service Y-strainers shall be provided as shown on the drawings. Strainers shall be full port-full flow design manufactured of 304 or 316 stainless steel body. Y-strainers shall be furnished with flanged ends. The strainer screen shall be 1/32-inch perforation, easily removable, manufactured of the same material as the valve body.
- C. Stainless steel Y-strainers shall be provided as shown on the drawings. Strainers shall be full port-full flow design manufactured of 304 or 316 stainless steel body. Y-strainers shall be furnished with flanged ends. The strainer screen shall be 1/32-inch perforation, easily removable, manufactured of the same material as the valve body.
- D. PVC and CPVC y-strainers shall be provided in PVC and CPVC piping and as shown on the Drawings. Strainer shall be provided with PVC or CPVC body and end cap, EPDM or Viton seal as required for the chemical service, and 20 mesh screen. Temperature rating shall be 30°F to 140°F, and pressure rating shall be 150 psi @ 70°F, non-shock. PVC and CPVC y-Strainers shall be as manufactured by Asahi/America, Hayward, or equal.
- E. Manually cleaned strainers shall be the duplex basket tapered plug type.
  - 1. Strainers 3-inches in diameter and larger shall have flanged ends conforming to ANSI B16.1-125/150-pound standard.
  - 2. Strainers less than 3-inches in diameter shall have screwed end connectors, unless otherwise shown on the Drawings.
  - 3. Strainers shall be constructed with an ASTM A48, Class 30 cast iron body, ductile iron trim, removable 0.045-inch staggered hole perforation, 304 stainless steel filter baskets and gauges on the inlet and outlet.
  - 4. All strainers shall be suitable for 125 psi service.
  - 5. Switching flow from one basket to the other shall be accomplished by moving the handle through a 180° arc. The switching operation shall not stop flow through the strainer and shall provide for on-line removal of either basket with the other basket functional. The plug shall be automatically positioned with integral stops and shall be easily lifted and reseated under pressure.
  - 6. The strainer shall be designed to minimize the possibility of material bypassing the plug while being rotated and to prevent debris from building up under the plug. The strainer covers shall be designed for quick opening with swing away yoke.
  - 7. Each basket compartment shall have a side drain outlet.

8. All strainers shall be provided with support legs.
  9. Duplex basket strainers shall be similar to the Model 53BTX as manufactured by Hayward, or equal.
- F. PVC and CPVC simplex basket strainers shall be provided in PVC and CPVC piping as shown on the Drawings. 1/2"-4" strainers shall be one-piece molded body with (3) ports to facilitate straight-thru flow pattern or u-shape flow pattern as required. Connections shall be true union type to ease installation/future maintenance. The cover, vent plug, and drain plug shall all be hand-removable, requiring no tools. EPDM or Viton seals shall be used as required for chemical service, and internal baskets shall be 1/32" perforation (20-mesh) for 1/2"-1" sizes, and 1/8" perforation for 1-1/2"-8" sizes. 6" and 8" strainers shall be fabricated construction and shall contain flanged connections as standard. The pressure rating for 1/2"-8" sizes shall be 150 psi @ 70°F, non-shock. Strainers shall be manufactured by Hayward Industrial Products, or equal.

## **2.06 QUICK DISCONNECT COUPLINGS**

- A. Quick disconnect type coupling for compressed/service air shall be provided where indicated on the Drawings. Coupling shall provide for instantaneous shutoff in socket end when lines are disconnected. Couplings shall be constructed of 316 stainless steel with a BUNA-N O-ring and integral safety lock. Couplings shall comply with Military Specification 4109 (interchangeable with standard plug of the same size).

## **2.07 BACKFLOW PREVENTERS**

- A. Backflow preventer shall be the size shown on the Drawings and shall be of the double check valve principle. Backflow preventer installation shall include isolation valves and four test cocks, furnished as an assembly. For backflow preventers less than 2-1/2", the installation assembly also shall include a strainer. Isolation valves for backflow preventers shall be ball valves, except for size 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The backflow preventer shall be a WATTS 709, or equal.
- B. Reduced Pressure Backflow Preventer shall be of the size shown on the Drawings and shall be of the reduced pressure principle type in accordance with AWWA Standards C510 and C511, with two (2) independent operating spring loaded check valves and one (1) spring loaded, diaphragm actuated, differential pressure relief valve shall be installed between the check valves. Backflow preventer shall be bronze body construction, with EPT rubber discs and Buna-N and nylon diaphragm. Screws and springs shall be of stainless steel. End connections shall be screwed, unless otherwise specified or shown on the Drawings. Reduced pressure backflow preventer installations shall include isolation valves and four test cocks, furnished as an assembly. For reduced pressure backflow preventers less than 2-1/2" the installation assembly also shall include a strainer. Isolation valves for reduced pressure backflow preventers shall be ball valves,

except for sizes 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The reduced pressure backflow preventer shall be as manufactured by Beeco Division, Hersey Products Inc., Aergap Model 6CM, WATTS 909, or equal.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Except where noted otherwise herein, all valves shall be installing and tested in accordance with the latest revision of AWWA C500. Before installation, all valves shall be lubricated, manually opened and closed to check their operation and the interior of the valves shall be thoroughly cleaned. Valves shall be placed in the positions shown on the Drawings. Joints shall be made as directed under the Piping Specifications. The valves shall be so located that they are easily accessible for operating purposes and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.
- B. All valves shall be tested at the operating pressures at which the particular line will be used. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight. All motor operated and cylinder operated valves shall be tested for control operation as directed by the Engineer.
- C. Provide valves in quantity, size, and type with all required accessories as shown on the Drawings.
- D. Install all valves and appurtenances in accordance with manufacturer's instructions. Install suitable corporation stops at all points shown or required where air binding of pipe lines might occur. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor but without interfering with access, and as approved by Engineer. Unless otherwise approved, install all valves plumb and level. Valves shall be installed free from distortion and strain caused by misaligned piping, equipment or other causes.
- E. Valve boxes shall be set plumb and centered with the bodies directly over the valves so that traffic loads are not transmitted to the valve. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face, if less than 4 feet.

### **3.02 SHOP AND FIELD TESTING**

- A. Shop and field testing of valves shall be as follows:
  - 1. Certified factory testing shall be provided for all components of the valve and operator system. Valves and operators shall be shop tested in accordance with the requirements in the latest revision of AWWA C500, including performance tests,



leakage test, hydrostatic tests, and proof-of-design tests. The manufacturer through the Contractor shall submit certified copies of the reports covering the test for acceptance by the Engineer.

2. Shop testing shall be provided for the operators consisting of a complete functional check of each unit. Any deficiencies found in shop testing shall be corrected prior to shipment. The system supplier through the Contractor shall submit written certification that shop tests for the electrical/pneumatic system and all controls were successfully conducted and that these components provide the functions specified and required for proper operation of the valve operator system.
3. The Contractor shall conduct field tests to check and adjust system components, and to test and adjust operation of the overall system. Preliminary field tests shall be conducted prior to start-up with final field tests conducted during start-up. The factory service representative shall assist the Contractor during all field testing and prepare a written report describing test methods, and changes made during the testing, and summarizing test results. The service representative shall certify proper operation of the valve operator system upon successful completion of the final acceptance field testing.
4. Preliminary and final field tests shall be conducted at a time approved by the Engineer. The Engineer shall witness all field testing.
5. All costs in connection with field testing of equipment such as energy, light, lubricants, water, instruments, labor, equipment, temporary facilities for test purposes, etc. shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.
6. Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components. Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly. The preliminary field test report must be approved by the Engineer prior to conducting final field acceptance tests. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation specified or otherwise directed by the Engineer.
7. Final field acceptance tests shall be conducted simultaneously with the start-up and field testing of the pumps, air compressors, process air blowers, etc. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified

conditions of opening and closing. Performance of pneumatic valves and compressed air system under normal operating conditions and during simulated power failures shall be checked.

8. Field testing shall include optimization of opening and closing times of the valves. The Contractor shall provide the means for accurate measurement of pipeline pressures as directed by the Engineer. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

**END OF SECTION**

**SECTION 40 05 57**  
**VALVE OPERATORS AND ELECTRIC VALVE ACTUATORS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and Section 40 05 00 – Basic Mechanical Requirements.
- B. The electric valve actuators shall meet the signal requirements described in Section 40 61 23 – Signal Coordination, Section 40 61 93 – Process Control System Input/Output List, and Section 40 61 96 – Process Control Descriptions.
- C. Valve operators and electric valve actuators shall be designed to unseat, open or close, and seat the valve under the most adverse operating condition to which the valves will be subjected.
- D. Operator mounting arrangements shall be as indicated on the Drawings or as directed by the manufacturer and/or Engineer. There shall be no mounting restrictions on the electric valve actuator.
- E. The valve operators and electric actuators shall be the full and undivided responsibility of the valve manufacturer in order to ensure complete coordination of the components and to provide unit responsibility.

**1.02 SUBMITTALS**

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures; and Section 46 00 00 – Equipment General Provisions:
  - 1. Shop Drawings
  - 2. O&M Manuals
  - 3. Certification that the force required to operate all valves is as specified herein.

**PART 2 – PRODUCTS**

**2.01 GENERAL**

- A. Electric actuators shall be provided where specified in the Drawings.

- B. Manual operators shall be provided on all valves which do not receive electric actuators. Manual operator type shall be as specified herein and as shown on the Drawings.
- C. Quarter turn valves 8" and greater in size shall have geared operators. Gate valves 14" and greater in size shall have geared operators.
- D. Operators/actuators shall be furnished with conservatively sized extension bonnets, extension stems, or torque tubes, and all required appurtenances required for a complete installation. Operators furnished with extension bonnets shall include stainless steel extension stems, or stainless steel torque tubes.

## **2.02 MANUAL OPERATORS**

- A. Unless otherwise specified or shown on the Drawings, manual operator type shall be as follows:
  - 1. Buried valves shall be equipped with nut operators, extended stems, and valve boxes. Where the depth of the operating nut is more than 4 feet below finish grade, a valve operator extension shall be provided to bring the operating nut to within 18-24 inches of the surface.
  - 2. Exposed valves up to 6-inch shall be lever operated (except gate valves).
  - 3. Exposed valves 8-inches and larger shall be handwheel operated.
  - 4. Exposed gate valves shall be handwheel operated.
  - 5. Valves with centerline of operator located more than 6-feet above the floor or platform from which it is to be operated shall have a chainwheel operator unless otherwise indicated on the Drawings.
- B. Manual operators shall be rigidly attached to the valve body unless otherwise specified or shown on the Drawings.
- C. All operators shall turn counter-clockwise to open and shall have the open direction clearly and permanently marked.
- D. Valve operators shall be designed so that the force required to operate the handwheel, lever, or chain (including breakaway torque requirements) does not exceed 80 pounds applied at the extremity of handwheel or chainwheel operator. Design pressures for sizing of valve operators shall be the piping test pressure for the piping on which the valve is to be installed.
- E. Handwheels for valves operators shall not be less than 12 inches in diameter. The maximum diameter of any handwheel shall not exceed 24".

- F. Nut operators shall have standard 2-inch square AWWA operating nuts designed in accordance with AWWA C504-94.
- G. Geared manual operators shall be of the worm gear, traveling nut or scotch yolk type except manual operators for butterfly valves 18-inch in diameter or larger which shall be worm gear, unless otherwise indicated in the individual valve specification. Gear operators shall be of the worm gear or bevel gear type. Gear box designs incorporating end of travel stops in the housing shall be equipped with AWWA input stops. Each gearbox shall require a minimum of 10 turns for 90 degree rotation or full valve stem travel and shall be equipped with a mechanical valve position indicator.
- H. Manual operators on below grade (and vault installed) valves shall be permanently lubricated and watertight under an external water pressure of 10 psi.

**PART 3 – EXECUTION**

**3.01 MANUFACTURER’S FIELD SERVICES**

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits for electric actuators:

<b>Service</b>	<b>Number of Trips</b>	<b>Number of Days/Trip</b>
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

**3.02 INSTALLATION**

- A. All valve actuators shall be installed in accordance with the manufacturer's published recommendations and the applicable specification sections for valves, and motor controls.
- B. Valve actuators shall be factory coated in accordance with the manufacturer’s standard paint system.

**3.03 SHOP TESTING**

- A. Shop testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:
  - 1. Conduct a complete functional check of each unit. Correct any deficiencies found in shop testing prior to shipment.

2. Submit written certification that:
  - a. Shop tests for the electrical system and all controls were successfully conducted;
  - b. Electrical system and all controls provide the functions specified and required for proper operation of the valve operator system.
3. Each actuator shall be performance tested and individual test certificates shall be supplied free of charge. The test equipment shall simulate each typical valve load and the following parameters should be recorded:
  - a. Current at maximum torque setting
  - b. Torque at maximum torque setting
  - c. Flash Test Voltage
  - d. Actuator Output Speed or Operating Time
  - e. In addition, the test certificate should record details of specification, such as gear ratios for both manual and automatic drive, closing direction, and wiring diagram code number.
  - f. Verification of actuator torque rating with valve.

### **3.04 FIELD TESTS**

- A. Field testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:
  1. Valve actuators shall be field-tested together with the associated valves.
  2. Test all valves at the operating pressures at which the particular line will be used.
  3. Test all valves for control operation as directed.
  4. Field testing shall include optimization of opening and closing times of the valves. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.
- B. Preliminary Field Tests
  1. General: Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components.

2. Scope: Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly.
3. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation, as specified or otherwise directed.

C. Final Field Tests

1. Final field tests shall be conducted in accordance with the latest revision of AWWA C500.
2. Final field tests shall be conducted simultaneously with the start-up and field testing of the pumps.
3. Final field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.
4. Certification of Equipment Compliance: After the final field tests are completed and passed, submit affidavit according to Section 46 00 00 – Equipment and General Provisions.

**END OF SECTION**

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**SECTION 40 05 58**  
**GATE OPERATORS AND ELECTRIC GATE ACTUATORS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and Section 40 05 00 – Basic Mechanical Requirements.
- B. Gate operators shall be designed to unseat, open or close, and seat the gate under the most adverse operating condition to which the gates will be subjected.
- C. Operator mounting arrangements shall be as indicated on the Drawings or as directed by the manufacturer and/or Engineer.
- D. The gate operators shall be the full and undivided responsibility of the gate manufacturer in order to ensure complete coordination of the components and to provide unit responsibility.

**1.02 SUBMITTALS**

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures; and Section 46 00 00 – Equipment General Provisions:
  - 1. Shop Drawings
  - 2. O&M Manuals
  - 3. Certification that the force required to operate all gates is as specified herein.

**PART 2 – PRODUCTS**

**2.01 GENERAL**

- A. Electric actuators shall be provided where specified in the Drawings. Manual operators shall be provided on all gates which do not receive electric actuators.
- B. Manual operators and electric actuators shall be mounted on either a floorstand or a benchstand as shown on the Drawings.
  - 1. Floorstands shall consist of a cast iron pedestal designed to position the input shaft or handwheel approximately 36-inches above the operating floor.

Floorstands shall be of the straight or offset design as specified herein or as shown on the Drawings.

2. Benchstands shall be provided with a rectangular cast iron base machined and drilled for mounting purposes.
- C. All operators/actuators shall be provided with a clear, butyrate plastic rising stem cover to protect the rising stem from moisture, dirt, and damage.
1. The stem cover shall not discolor or become opaque for a minimum of five (5) years after installation.
  2. "Fully Open" and "Fully Closed" positions shall be marked on each cover with mylar labels.
  3. Covers shall be graduated in one (1) inch increments.
  4. The top of the stem cover shall be closed and the bottom shall be designed for easy field mounting to the gearbox.
  5. The bottom of the stem cover shall be designed to mount to the gearbox in such a way that all moisture is drained out to protect the stem and gearbox. Accumulated moisture of any amount on top of the gearbox inside the stem cover is unacceptable.

## **2.02 MANUAL OPERATORS**

- A. Manual operators shall be provided by the gate manufacturer. Manual operators shall be handwheel or handcrank operated as indicated on the Drawings and specified in the Gate Schedule.
1. Manual operation shall require no greater than a 40 pound pull on the crank or handwheel with the specified operating head on the gate.
  2. Manual operators shall be provided with a threaded cast bronze lift nut to engage the operating stem. Tapered anti-friction roller or ball thrust bearings shall be provided above and below a flange on the operating nut to support both opening and closing thrusts.
  3. Lubricating fittings and extensions shall be provided for the lubrication of all gears and bearings.
  4. An arrow with the word "open" shall be permanently attached or cast on the floorstand, benchstand, or handwheel indicating the direction of rotation to open the gate. Unless otherwise noted, all operators shall turn counter-clockwise to open.

5. All sluice gates and slide gates 3 ft. wide and larger shall be crank-operated, unless otherwise indicated herein as shown on the Drawings.
- B. Handwheel operators shall be furnished without gear reduction. The removable handwheel shall be fabricated steel or cast iron, designed for rough treatment and minimum weight. Handwheels shall not be less than 12 inches in diameter. The maximum diameter of any handwheel shall not exceed 24 inches.
- C. Crank-operated type manual operators shall have either single or double gear reduction depending upon the lifting capacity required.
1. Crank operators shall be suitable for operation by a portable gate operator.
  2. Gearing shall be steel or cast iron with machine cut teeth designed for smooth operation.
  3. The pinion shafts on crank-operated floorstands, either single or double, shall be stainless steel, and supported on tapered roller bearings.
  4. All components shall be totally enclosed in a cast iron weather-proof housing with cover.
  5. Positive mechanical seals shall be provided on the operating nut and the pinion shafts where they extend from the cast iron case or gear box to retain lubricant and to exclude moisture and dirt.
  6. The removable crank shall be cast iron with a revolving brass grip.

**PART 3 – EXECUTION**

**3.01 MANUFACTURER’S FIELD SERVICES**

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits for electric actuators:

<b>Service</b>	<b>Number of Trips</b>	<b>Number of Days/Trip</b>
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

### **3.02 INSTALLATION**

- A. All gate actuators shall be installed in accordance with the manufacturer's published recommendations and the applicable specification sections for gates, and motor controls.
- B. Gate actuators shall be factory coated in accordance with the manufacturer's standard paint system.

### **3.03 SHOP TESTING**

- A. Shop testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:
  - 1. Conduct a complete functional check of each unit. Correct any deficiencies found in shop testing prior to shipment.
  - 2. Submit written certification that:
    - a. Shop tests for the electrical system and all controls were successfully conducted;
    - b. Electrical system and all controls provide the functions specified and required for proper operation of the gate operator system.
  - 3. Each actuator shall be performance tested and individual test certificates shall be supplied free of charge. The test equipment shall simulate each typical gate load and the following parameters should be recorded:
    - a. Current at maximum torque setting
    - b. Torque at maximum torque setting
    - c. Flash Test Voltage
    - d. Actuator Output Speed or Operating Time
    - e. In addition, the test certificate should record details of specification, such as gear ratios for both manual and automatic drive, closing direction, and wiring diagram code number.
    - f. Verification of actuator torque rating with gate.

### **3.04 FIELD TESTS**

- A. Field testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:

1. Gate actuators shall be field-tested together with the associated gates.
2. Perform field tests to check and adjust system components, and to test and adjust operation of the overall system, in accordance with Section 46 00 00 – Equipment General Provisions.
  - a. Preliminary field tests shall be conducted prior to start-up.
  - b. Final field tests conducted during start-up.
3. Preliminary and final field tests shall be conducted at a time approved by the Engineer.
4. Test all gates at the operating pressures at which the particular line will be used.
5. Test all gates for control operation as directed.
6. Field testing shall include optimization of opening and closing times of the gates. Gate opening and closing times shall be adjusted based on process requirements to optimize operation of the gates. Final gate opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

#### B. Preliminary Field Tests

1. General: Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire gate operator system and all system components.
2. Scope: Preliminary field tests shall demonstrate that the gate operator system performs according to specifications and that all equipment, gates, controls, alarms, interlocks, etc., function properly.
3. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required gate closing time and operation, as specified or otherwise directed.

#### C. Final Field Tests

1. Final field tests shall be conducted in accordance with the latest revision of AWWA C500.
2. Final field tests shall be conducted simultaneously with the start-up and field testing of the pumps.
3. Final field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the gates shall be

tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.

4. Certification of Equipment Compliance: After the final field tests are completed and passed, submit affidavit according to Section 46 00 00 – Equipment General Provisions.

**END OF SECTION**

**SECTION 40 05 59.23**  
**FABRICATED STAINLESS-STEEL SLIDE GATES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install all fabricated stainless-steel slide gates complete with all accessories, special tools, spare parts, mountings, anchor bolts and other appurtenances as specified herein, as shown on the Drawings, and as required for a complete and operating installation. The gates and appurtenances shall be supplied in accordance with the latest edition of ANSI/AWWA C561 Fabricated Stainless-Steel Slide Gates, except as modified herein. Leakage shall not exceed 0.05 gallon per minute per foot of wet perimeter, which is half the allowable leakage rate listed in the latest revision of AWWA C561.
- B. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and Section 40 05 00 – Basic Mechanical Requirements.
- C. Manual and electric gate actuators (operators) shall be as specified in Section 40 05 58 – Gate Operators and Electric Gate Actuators.
- D. The Contractor shall coordinate all details, locations, clearances, and other conditions with the various equipment suppliers, so that the gates function as part of a complete system.

**1.02 SUBMITTALS**

- A. The following items shall be submitted with the Shop Drawings, in accordance with or in addition to, the submittal requirements specified in Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions:
  - 1. Shop drawings showing dimensions, general construction, and materials used for all parts of the gate and gate appurtenances. These drawings shall include sufficient detail to determine if the proposed equipment meets the requirements specified herein and must include individual drawings for each typical gate to be provided.
  - 2. Certification that submitted gates are in accordance with the latest edition of AWWA C561, except as modified herein.
  - 3. Design calculations demonstrating anchor bolt sizing and spacing in compliance with AWWA C561.

**PART 2 – PRODUCTS**

## **2.01 GENERAL**

- A. Subject to compliance with the Specifications, provide products manufactured by Fontaine-Aquanox, Golden Harvest, Hydro Gate, Rodney Hunt, Waterman, Whipps, or approved equal. The same manufacturer shall furnish all fabricated stainless-steel slide gate assemblies.
- B. The gates and appurtenances shall be designed for installation in the structures shown on the Drawings.
- C. Gates shall be configured as self-contained and shall be designed to mount directly to concrete (surface mounted or embedded) as indicated in the Drawings.
- D. Gates shall be either submerged or free surface gates as indicated in the Drawings.
  - 1. Submerged gates shall be sealed on all 4 sides.
  - 2. Free surface gates shall be sealed on the bottom and both sides.
- E. Gates shall be either flush bottom or conventional closure as shown on the Drawings.
- F. Gate actuators shall be as identified in the Drawings.
- G. Stainless-steel nameplates shall be permanently attached to each pedestal (floor stand), yoke (bench), or torque tube (bench stand), indicating gate invert elevation, and the Manufacturer's identification number.

## **2.02 FRAME AND GUIDES**

- A. The guides shall be integral with the frame. The frame assembly, including the guide members, invert member, and yoke member, shall be constructed of formed stainless steel plate with a minimum thickness of 1/4-inch.
- B. Flush-bottom closure type gates shall have a replaceable compressible resilient seal attached to the invert member of the frame. The seal shall be held in place with a retainer bar or molded into the frame invert. Designs that require the invert seal to be mounted on the slide shall not be allowed.
- C. The guides shall be provided with holes for anchor bolts at a maximum spacing of 18-inches.

## **2.03 SLIDE**

- A. The slide (disc) shall be stainless-steel plate reinforced with structural shapes of the same alloy welded to the plate.
- B. Slide deflection shall not exceed 1/720 of gate width at maximum design head, or 1/16 in., whichever is less.



## **2.04 ACTUATOR SUPPORT/MOUNTING**

- A. Self-contained gates shall be provided with a yoke machined to receive either a base-plate or torque tube for actuator mounting. The yoke shall be formed by two (2) angles or channels welded at the top of the guides to provide a one (1) piece rigid frame. The arrangement of the yoke shall be such that the stem and slide can be removed without disconnecting the yoke. At maximum operating load, yoke deflection shall not exceed 1/720 of gate width, or a maximum of ¼-inch, whichever is less.

## **2.05 STEMS AND STEM GUIDES**

- A. Unless otherwise indicated on the Drawings, all gates shall be rising stem.
- B. Operating stems shall be designed to transmit in compression at least 2-1/2 times the rated output of the operating mechanism with a 40-pound effort on the crank or handwheel, or 2 times the stalled motor torque of the electric actuator, whichever is greater.
- C. Stem design calculations shall use the stem minor diameter for calculating stem cross sectional area and stresses due to compression and tension loads.
- D. Keys or pins shall be stainless steel materials matching the alloy of the gate stem. All threaded and keyed couplings of the same size shall be interchangeable.
- E. Stem guides shall be adjustable in two directions and shall be placed according to Manufacturer's recommendation, but in no case shall spacing exceed 10 feet on center. In addition, stem slenderness ratio ( $l/r$ ) shall not be greater than 200.
- F. Rising stem gates shall be provided with an adjustable stop collar on the stem above and below the actuator lift nut. Collars below the nut shall not be required for self-contained gates where the frame height equals the gate height plus the range of travel of the slide.

## **2.06 MATERIALS**

- A. Materials for gates shall conform to the following specifications:
  - 1. Thimble, frame, guides, slide, yoke, stem, stem guides, stem couplings, rising-stem thrust nuts, and flush bottom seal retainer – ASTM A276, Type 316 stainless steel.
  - 2. Non-rising stem thrust nuts and gate actuator lift nut – B584, CA 865 bronze.
  - 3. Seats and stem guide bushings – ASTM D4020 UHMW-PE.
  - 4. Seals – Neoprene, EPDM, or UHMW-PE.
  - 5. Flush-bottom seal – Neoprene or EPDM.

6. Wedges (if required) – ASTM A276 Type 316 stainless steel or UHMW-PE.
7. Bolts, fasteners, and hardware – ASTM A276, Type 316 stainless steel.

## **PART 3 – EXECUTION**

### **3.01 MANUFACTURER’S FIELD SERVICES**

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits for each series of gates:

<b>Service</b>	<b>Number of Trips</b>	<b>Number of Days/Trip</b>
Installation and Testing	1	1
Startup and Training	1	1

### **3.02 INSTALLATION AND TESTING**

- A. Installation - The gates shall be set carefully in the locations shown on the Drawings in accordance with the installation manual furnished by the gate manufacturer.
  1. The stems shall be provided with wall-mounted guides where required.
  2. All gates shall be operated and tested to assure proper installation.
- B. Concrete Surface Mounting/Grouting – once gate has been properly anchored per manufacturer’s requirements, gate shall be formed and grouted with flowable non-shrink grout per Section 03 60 00 – Grout to fill all voids between gate frame and wall. Dry packing of grout shall not be considered acceptable.
- C. Testing - The completely assembled and installed gates shall be inspected for proper seating.
  1. The gate slide shall be fully opened and closed in its guide system to ensure that it operates freely.
  2. Pedestals shall be shop-operated to ensure proper assembly and operation.
- D. All gates shall be certified that at the operating head conditions indicated on the Gate Schedule, leakage shall not exceed 0.05 gallon per minute per foot of wet perimeter.

### **3.03 PAINTING**

- A. All ferrous parts, except stainless steel, of the gates and stem guides shall be blast-cleaned and painted in accordance with Section 09 90 00 – Painting.
- B. All machined iron surfaces, including drilled and tapped holes, shall be coated with a protective grease.
- C. The surfaces of the wall thimbles in contact with concrete shall remain uncoated.

**END OF SECTION**

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## SECTION 40 05 62

### PLUG VALVES

#### PART 1 – GENERAL

##### 1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

#### PART 2 – PRODUCTS

##### 2.01 PLUG VALVES

- A. Plug valves shall be of the non-lubricated, eccentric seating plug type with synthetic rubber-faced plugs as manufactured by DeZurik Company, Pratt, Milliken, or equal. All valves shall be provided with limit stops and rotate 90° from fully-open to fully-shut. The minimum working pressure for all valves shall be 150 psi, and the test pressure shall be at least 270 psi for valves up through 12-inch and at least 230 psi for valves 14-inch and larger. The port area of valves shall be at least 80 percent of full pipe area for valves less than 24-inches and 70 percent for valves 24-inches and larger, unless otherwise specified in the Drawings. The body materials shall be of epoxy coated cast iron or semi-steel, unless specified otherwise. Seats shall have a welded overlay of 90 percent pure nickel and machined to a finish containing no stress cracks. Plug facings shall be of Hycar, or equal and completely suitable for use with domestic sewage.
- B. The shaft seal shall be either the bronze cartridge type with at least two O-Rings, monolithic V-Type, U-Cup Type, or pull down packing type. If monolithic V-Type, U-Cup Type, or pull down packings are utilized, it shall be self-adjusting, self-compensating type. Packing shall be as manufactured by Chevron, or equal. Plug valves with pull down packings shall be designed with an extension bonnet so that repacking can be done without removal of the actuator.
- C. All buried valves shall have mechanical joint ends (unless otherwise shown), conforming to ANSI A21.11 (AWWA C 111), and shall be operated with a standard AWWA 2-inch square nut through a totally enclosed worm gear actuator. Valve boxes shall be installed with all buried plug valves and shall be as specified herein.
- D. Unless otherwise shown, all exposed valves 4-inches in diameter and larger shall have flanged ends conforming to ANSI B16.1-125/150 pound standard with face-to-face dimensions of standard plug valves. Valves smaller than 4-inches in diameter shall have screwed ends, unless otherwise noted.
- E. Valves 8-inches in diameter and larger shall be handwheel or floorstand operated where required or indicated on the Drawings through totally enclosed worm gear actuators,

unless otherwise specified or shown on the Drawings. Valves 6-inches in diameter and smaller shall have lever operators, unless otherwise specified or noted on the Drawings. Manual operators for plug valves mounted above 6 feet from the operating floor shall be equipped with worm gear chainwheel actuators.

- F. The manufacturer shall certify that the plug valves are capable of operating in continuous duty service under these pressures and flow conditions.
- G. Each valve shall be hydrostatically tested and tested for bubble tightness after the operator has been mounted and adjusted. Copies of the hydrostatic and leakage test certification and certification of conformance shall be submitted to the Engineer prior to shipment.
- H. All internal and external ferrous components and surfaces of the valves, with the exception of stainless steel and finished or bearing surfaces, shall be shop painted with two coats (10 mils min. dry film thickness) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations.

**END OF SECTION**

**SECTION 40 05 65.23**  
**CHECK VALVES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.
- B. Valves intended for chemical service shall be constructed of materials suitable for the intended service.

**PART 2 – PRODUCTS**

**2.01 SWING CHECK VALVES**

- A. Check valves larger than 3-inches shall be resilient hinge check valves rated for a minimum working pressure of 175 psi and shall be manufactured by Val-Matic, DeZurik APCO, or equal. The check valve shall be designed, manufactured, tested and certified to AWWA C508, latest edition.
- B. Valve body and cover shall be constructed of Grade 65-45-12 ductile iron or Class B gray iron fully conforming to the latest revision of ASTM A536 or ASTM A126, respectively. Valve ends shall be Standard American 125 pound flat-faced flanged, in accordance with ANSI B16.1.
- C. The valve disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface and reinforced with ally steel. The flex portion of the disc contains nylon reinforcement. The disc shall be made of Buna-N (NBR, ASTM D2000-BG).
- D. The disc accelerator shall be of one-piece construction and provide rapid closure of the valve in high head applications. The disc accelerator shall be enclosed within the valve and shall be field adjustable and replaceable without removal of the valve from the line.
- E. The valve shall be provided with a threaded port with pipe plug on the bottom of the valve to allow for field installation of a future backflow actuator or without removing the valve from the line.

- F. With the exception of the valve body and seat, all parts in contact with water shall be manufactured from noncorrosive materials. Internal corrosive surfaces shall be shop painted with two coats of epoxy for corrosion resistance. Exterior surfaces shall be painted in accordance with the requirements of Section 09 90 00 – Painting.

**END OF SECTION**



**SECTION 40 05 68.23**  
**MISCELLANEOUS VALVES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

**PART 2 – PRODUCTS**

**2.01 PRESSURE RELIEF, REDUCING AND REGULATING VALVES**

- A. Pressure relief valves (wastewater service) shall be diaphragm activated, single seat, pilot operated and shall maintain a constant upstream pressure by relieving excess pressure.
- B. The valve shall be normally closed and shall open to maintain the required back pressure when the valve inlet pressure reaches the pilot control set point.
- C. The initial pilot control setting shall be provided by the Engineer prior to installation.
- D. The stem shall be stainless steel and shall be guided through the center for 100% of the stem travel.
- E. The main valve throttling plug shall be provided with V-port sections to insure precise control at low flow rates.
- F. All internal metal parts shall be bronze or stainless steel.
- G. The control pilot shall be direct acting, spring loaded, and adjustable with bronze body and stainless-steel trim.
- H. The diaphragm and seat disc shall be BUNA-N.
- I. The valve shall be of the globe pattern as shown on the Drawings and shall be fully repairable in the line.
- J. Wastewater pressure reducing valve shall be manufactured by Cla-Val or equal.

**2.02 SEWAGE AIR AND VACUUM/PRESSURE AIR RELEASE VALVES**

- A. Description and Service
  - 1. Valve shall have the following functions: continuous discharge of dis-entrained pressurized air/gas, unrestricted vacuum break, and pipeline surge protection in a

single chamber. Valves shall be anti-surge and anti-shock air release and vacuum break valves.

- a. The small orifice shall release air accumulations after the pipeline is filled, under pressure and in operation.
- b. The valve shall be equipped with an integral surge alleviation mechanism that automatically dampens surge pressures due to rapid air discharge or the subsequent rejoining of separated water columns

**B. Construction and Design**

- 1. The intake/discharge orifice area is equal to the nominal size of the valve, i.e., an 8" valve shall have 8" full flow inlet and 8" outlet.
- 2. Nozzle and Anti-Shock floats shall be solid unbreakable HDPE that will not deform under twice the design working pressure.
- 3. Manufacturer shall have ISO 9001, and third-party vacuum testing to certify sizing and performance.
- 4. Valve shall have a 10-year in-service warranty for all internal components

**C. Materials of Construction**

- 1. Fusion Bonded Ductile Cast Iron Body, 304 Stainless Steel Top Cover and Fasteners
- 2. 304 Stainless Steel Body, Flange, Top Cover and Fasteners
- 3. 316 Stainless Steel Nozzle & Lower Float Assembly
- 4. Integral High Density Polyethylene Anti-Shock and Nozzle Floats
- 5. EPDM Seats and Seals
- 6. Tangential top and bottom Flushing Ports

D. The air valve shall be Vent-O-Mat Series RGXII, or equal.

E. Schedule:

Location	Size	ARV/PRV Model #	Connection
10" FM	2"	RGXII	Flanged

**END OF SECTION**

**SECTION 40 05 81**  
**FIRE, WALL AND YARD HYDRANTS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

**PART 2 – PRODUCTS**

**2.01 YARD HYDRANTS**

- A. Service water system hydrants shall be of the 2-inch non-freeze post-yard type with bronze casing, neoprene plunger. The barrel shall be self-draining; operating parts must be removable through the top of the hydrant.
- B. The cold-rolled steel stem shall operate with a bronze operating nut. Stem threads shall be lubricated through the top of the operating nut tapped for grease fittings. Packing shall be double "O" rings to insure a positive shutoff with a minimum of packing friction when the hydrant is being operated. Each hydrant shall be equipped with suitable adapters to connect 2-inch and 3/4-inch hoses.
- C. Each hydrant shall be supplied with 10-inch operating hand wheel and a steel post-mounted hose rack.
  - 1. The hydrants shall be Models 71702 as manufactured by Josam, Z-1390 as manufactured by Zurn, 5914 by Smith Company, or equal.

**PART 3 – EXECUTION (NOT USED)**

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**SECTION 40 61 13**  
**PROCESS CONTROL SYSTEM GENERAL PROVISIONS**

**PART 1 – GENERAL**

**1.01 SCOPE**

- A. The Contractor shall provide, through the services of an instrumentation and control system subcontractor, components, system installation services, as well as required and specified ancillary services in connection with the Instrumentation, Control and Information System.
- B. The System includes materials, labor, tools, fees, charges, and documentation required to furnish, install, test and place in operation a complete and operable instrumentation, control and information system.
- C. The system shall include measuring elements, signal converters, transmitters, local control panels, digital hardware and software, operator workstations, remote telemetry units, signal and data transmission systems, interconnecting wiring, and pertinent accessories.
- D. The scope of the work to be performed under this Division includes but is not limited to the following:
  - 1. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.
  - 2. Furnish and install process instrumentation and associated taps and supports as scheduled or shown on the Drawings, unless otherwise noted or supplied by equipment vendors.
  - 3. Furnish and install local control panels, field panels and associated cabinets and panels as shown on the Drawings and as specified in Sections 40 61 13 through 40 79 00, inclusive.
  - 4. Furnish and install digital control system hardware and software as specified in Sections 40 61 13 through 40 79 00, inclusive.
  - 5. Provide PLC-based panel with cellular modem as specified in Section 40 66 00 to receive inputs from pump station devices and communicate with Owner's SCADA system through their Verizon cellular service provider.
  - 6. Provide HMI screen(s) for lift station equipment and process matching the style of the Owner's existing screens and using Drawing I101 as a guide.

7. Provide combustible gas monitoring system as shown on the Drawings and as specified in Sections 40 76 21 and 40 61 96.
  8. Provide pump station discharge flow measurement as shown on the Drawings and as specified in Sections 40 71 13.13 and 40 61 96.
  9. Final termination and testing of instrumentation and control system signal wiring and power supply wiring at equipment furnished under Sections 40 60 00 through 40 79 99, inclusive and where included.
  10. Furnish, install and terminate special cables for devices (e.g., instruments, printers, radios). Furnish and terminate control system communication network cables.
  11. Furnish and install surge protection devices for digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division, including connections to grounding system(s) provided under Division 26.
  12. Coordinate grounding requirements with the electrical subcontractor for digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division. Terminate grounding system cables at equipment provided under this Division.
  13. Provide system testing, calibration, training and startup services as specified herein and as required to make systems fully operational.
- E. It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials that may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

## **1.02 RELATED ITEMS**

- A. Field mounted switches, torque switches, limit switches, gauges, valve and gate operator position transmitters, sump pump controls, and other instrumentation and controls furnished with mechanical or electrical equipment not listed in the instrument schedule shall be furnished, installed, tested, and calibrated as specified under other Divisions unless otherwise indicated.
- B. Additional and related work performed under Division 26 includes the following:
  1. Instrument A.C. power source and disconnect switch for process instrumentation, A.C. grounding systems, and A.C. power supplies for equipment, control panels and accessories furnished under Sections 40 60 00 through 40 79 99, inclusive and where included.

2. Conduit and raceways for instrumentation and control system signal wiring, grounding systems, special cables and communication network cables.
3. Instrumentation and control system signal wiring.
4. Install control system communication network cables.
5. Furnish and install grounding systems for digital equipment, local control panels, remote telemetry units, and instrumentation provided under Sections 40 60 00 through 40 79 99, inclusive and where included. Grounding systems shall be complete to the equipment provided under Sections 40 60 00 through 40 79 99, inclusive, and where included, ready for termination by the instrumentation subcontractor.
6. Termination of instrumentation and control system signal wiring at equipment furnished under other divisions of the Specifications.
7. Final wiring and termination to A.C. grounding systems and to A.C. power sources (e.g., panelboards, motor control centers, and other sources of electrical power).

### **1.03 GENERAL INFORMATION AND DESCRIPTION**

- A. Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings.
- B. In order to centralize responsibility, it is required that equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating signals, and furnishing appurtenant equipment.
- C. The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be responsible for the delivery of detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment/systems and shall provide for the services of a qualified installation engineer to supervise activities required to place the completed facility in stable operation under full digital control.
- D. The instrumentation and control system shall be capable of simultaneously implementing all real time control and information system functions, and servicing all operator service

requests as specified, without degrading the data handling and processing capability of other system components.

- E. Control system inputs and outputs are listed in Section 40 61 93 – Process Control System Input/Output List. This information, together with the functional control descriptions, process and instrumentation diagrams, and electrical control schematics, describes the real time monitoring and control functions to be performed. In addition, the system shall provide various human/machine interface and data reporting functions as specified in the software sections of this Specification.
- F. The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect equipment, panels, instrumentation, controls, and appurtenances, either existing or furnished on the Project to determine requirements for interfacing with the control and information system. The Contractor shall coordinate the completion of required modifications with the associated supplier of the item furnished.
- G. The instrumentation subcontractor shall review and approve the size and routing of instrumentation and control cable and conduit systems furnished by the electrical subcontractor for suitability for use with the associated cable system.
- H. The Contractor shall coordinate the efforts of each supplier to aid in interfacing systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the electrical subcontractor and to the instrumentation subcontractor furnishing the equipment under this Division.
- I. The Contractor shall be responsible for providing a signal transmission system free from electrical interference that would be detrimental to the proper functioning of the instrumentation and control system equipment.
- J. The Owner shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to observe materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records, and certifications during all stages of design, fabrication, and tests. The instrumentation subcontractor and his equipment suppliers shall furnish office space, supplies, and services required for these observation activities.
- K. The terms "Instrumentation," "Instrumentation and Control System," and "Instrumentation, Control and Information System" shall hereinafter be defined as equipment, labor, services, and documents necessary to meet the intent of the Specifications.



#### **1.04 INSTRUMENTATION AND CONTROL SYSTEM SUBCONTRACTORS**

- A. Instrumentation and control system subcontractors shall be regularly engaged in the detailed design, fabrication, installation, and startup of instrumentation and control systems for water and wastewater treatment facilities, remote telemetry systems for water supply/distribution systems, and remote telemetry systems for wastewater collection systems. Instrumentation and control system subcontractors shall have a minimum of five years of such experience and shall have completed a minimum of three projects of similar type and size as that specified herein. Where specific manufacturers/models of major hardware or software products (PLC, HMI software, network, etc.) are specified to be used on this project, the instrumentation and control system subcontractor shall have completed at least one project using that specified hardware or software. As used herein, the term “completed” shall mean that a project has been brought to final completion and final payment has been made.
- B. Acceptable instrumentation and control system subcontractor shall be M/R Systems, Inc.

#### **1.05 DEFINITIONS**

- A. Solid State: Wherever the term solid state is used to describe circuitry or components in the Specifications, it is intended that the circuitry or components shall be of the type that convey electrons by means of solid materials such as crystals or that work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, mechanical relays, stepping motors or other devices will not be considered as satisfying the requirements for solid state components of circuitry.
- B. Bit or Data Bit: Whenever the terms bit or data bit are used in the Specification, it is intended that one bit shall be equivalent to one binary digit of information. In specifying data transmission rate, the bit rate or data bit rate shall be the number of binary digits transmitted per second and shall not necessarily be equal to either the maximum pulse rate or average pulse rate.
- C. Integrated Circuit: Integrated circuit shall mean the physical realization of a number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.
- D. Mean Time Between Failures (MTBF): The MTBF shall be calculated by taking the number of system operating hours logged during an arbitrary period of not less than six months and dividing by the number of failures experienced during this period plus one.
- E. Mean Time to Repair (MTTR): The MTTR shall be calculated by taking the total system down time for repair over an arbitrary period of not less than six months coinciding with that used for calculation of MTBF and dividing by the number of failures causing down time during the period.

- F. Availability: The availability of a non-redundant device or system shall be related to its MTBF and MTTR by the following formula:

$$A = 100 \times (\text{MTBF} / (\text{MTBF} + \text{MTTR})) \text{ Percent}$$

The availability of a device or system provided with an automatically switched backup device or system shall be determined by the following formula:

$$A = A2 + 1 - ((1 - A1) * (1 - A1))$$

where:

A1 = availability of non-redundant device or system

A2 = availability of device or system provided with an automatically switched backup device or system

- G. Abbreviations: Specification abbreviations include the following:

1. A - Availability
2. ADC - Analog to Digital Converter
3. AI - Analog Input
4. AO - Analog Output
5. AVAIL - Available
6. BCD - Binary Coded Decimal
7. CSMA/CD - Carrier Sense Multiple Access/Collision Detect
8. CPU - Central Processing Unit
9. CRC - Cyclic Redundancy Check
10. CS - Control Strategy
11. DAC - Digital to Analog Converter
12. DBMS - Data Base Management System
13. DI - Discrete Input
14. DMA - Direct Memory Access
15. DO - Discrete Output

16. DPDT - Double Pole, Double Throw
17. DVE - Digital to Video Electronics
18. EPROM - Erasable, Programmable Read Only Memory
19. FDM - Frequency Division Multiplexing
20. FSK - Frequency Shift Keyed
21. HMI - Human Machine Interface (Software)
22. I/O - Input/Output
23. LAN - Network and Communication Equipment
24. LCD - Liquid Crystal Display
25. LDFW - Lead Follow
26. MCC - Motor Control Center
27. MTBF - Mean Time Between Failures
28. MTTR - Mean Time to Repair
29. OS - Operating System
30. PAC - Programmable Automation Controller
31. PCB - Printed Circuit Board
32. PID - Proportional Integral and Derivative Control
33. PLC - Programmable Logic Controller or Programmable Controller
34. PROM - Programmable Read Only Memory
35. RAM - Random Access Memory
36. RDY - Ready
37. RMSS - Root Mean Square Summation
38. RNG - Running
39. ROM - Read Only Memory

- 40. RTU - Remote Telemetry Unit
- 41. SPDT - Single Pole, Double Throw
- 42. ST/SP - Start/Stop
- 43. TDM - Time Division Multiplexing
- 44. UPS - Uninterruptible Power Supply
- 45. VFD - Variable Frequency Drive

H. To minimize the number of characters in words used in textual descriptions on displays, printouts and nameplates, abbreviations may be used subject to the Engineer's approval. If a specified abbreviation does not exist for a particular word, an abbreviation may be generated using the principles of masking and or vowel deletion. Masking involves retaining the first and last letters in a word and deleting one or more characters (usually vowels) from the interior of the word.

## **1.06 ENVIRONMENTAL CONDITIONS**

- A. Instrumentation equipment and enclosures shall be suitable for ambient conditions specified. All system elements shall operate properly in the presence of telephone lines, power lines, and electrical equipment.
- B. Inside control rooms and climate-controlled electrical rooms, the temperature will normally be 20 to 25 degrees C; relative humidity 40 to 80 percent without condensation and the air will be essentially free of corrosive contaminants and moisture. Appropriate air filtering shall be provided to meet environmental conditions (e.g., dust).
- C. Other indoor areas may not be air conditioned/heated; temperatures may range between 0 and 40 degrees C with relative humidity between 40 and 95 percent.
- D. Field equipment including instrumentation and panels may be subjected to wind, rain, lightning, and corrosives in the environment, with ambient temperatures from -20 to 40 degrees C and relative humidity from 10 to 100 percent. All supports, brackets, interconnecting hardware, and fasteners shall be aluminum, type 316 stainless steel, or metal alloy as otherwise suitable for chemical resistance within chemical feed/storage areas shown on the installation detail drawings.

## **PART 2 – PRODUCTS (NOT USED)**

## **PART 3 – EXECUTION**

### **3.01 SCHEDULE OF PAYMENT**

- A. Payment to the Contractor for Control and Information System materials, equipment, and labor shall be in accordance with the General and Supplementary Conditions. The schedule of values submitted as required by the General and Supplementary Conditions shall reflect a breakdown of the work required for completion of the Control and Information System. The breakdown shall include sufficient detail to permit the Engineer to administer payment for the Control and Information System.
  
- B. The following payment schedule defines project milestones that will be used for establishing maximum partial payment amounts for the Control and Information System. Payment for field instruments, field wiring, fiber optic network cable and similar items will be made in addition to the payment for the scopes of services incorporated into the schedule below.
  - 1. Task Completed - Maximum Cumulative % Request for Payment
    - a. Mobilization - 3%
    - b. Preliminary Design Review - 5%
    - c. Approved Submittals - 20%
    - d. Hardware Purchase (excludes field instruments) - 40%
    - e. Factory Witness Test - 60%
    - f. Loop Checkout - 70%
    - g. Control System Start-up and Test - 80%
    - h. Plant Start-up - 90%
    - i. Final System Acceptance Test - 95%
    - j. Final Acceptance - 100%
  
- C. Requests for payment for materials and equipment that are not installed on site, but are required for system construction and the factory witness test (e.g., digital hardware), or are properly stored as described in the General and Supplementary Conditions and herein, shall be accompanied by invoices from the original supplier to the instrumentation subcontractor substantiating the cost of the materials or equipment.
  
- D. Any balance remaining within the schedule of values for field instruments and other materials installed on the site, or for other materials for which payment is made by invoice, will be considered due upon completion of the Final Acceptance test.

### **3.02 CLEANING**

- A. The Contractor shall thoroughly clean soiled surfaces of installed equipment and materials.
- B. Upon completion of the instrumentation and control work, the Contractor shall remove surplus materials, rubbish, and debris that has accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the Owner.

### **3.03 FINAL ACCEPTANCE**

- A. Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Engineer, and shall be based upon the following:
  - 1. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.
  - 2. Completion of the Availability Demonstration.
  - 3. Completion of control system training requirements.
  - 4. Completion of punch-list items that are significant in the opinion of the Engineer.
- B. Final acceptance of the System shall mark the beginning of the warranty period.

**END OF SECTION**

**SECTION 40 61 15**  
**PROCESS CONTROL SYSTEM SUBMITTALS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall submit for review complete Shop Drawings for all equipment in accordance with the General and Supplemental Conditions and Division 1 of the Specifications. All submittal material shall be complete, legible, and reproducible, and shall apply specifically to this project.
- B. All submittal materials shall be tailored to this project by highlighting relevant items or crossing out non-applicable items. Generic submittals without identified options will be returned the Contractor without review.
- C. Compliance, Deviations, and Exceptions (CD&E) Letter:
  - 1. Where a named manufacturer and product is specified and a substitution or an “or equal” product is submitted, the submittal shall be accompanied by a “Compliance, Deviations, and Exceptions (CD&E) letter.” If the required submittal is submitted without the letter, the submittal will be rejected.
  - 2. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor, subcontractor (if applicable), and the equipment Manufacturer/Supplier. This letter shall include a copy of the Specification Section to which the submittal pertains. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in.
    - a. The letter "C" shall be for full compliance with the requirement.
    - b. The letter "D" shall be for a deviation from the requirement.
    - c. The letter "E" shall be for taking exception to a requirement.
  - 3. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions shall not be acceptable.
  - 4. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 33 00 – Submittals

- B. Section 40 61 13 – Process Control System General Provisions

### **1.03 EXISTING CONDITIONS / AS-BUILT DOCUMENTATION SUBMITTAL**

- A. Prior to modifying, demolishing, removing, or decommissioning equipment, thoroughly investigate and document the existing conditions. Please note that Owner's record drawings alone are not sufficient for documentation. The record drawings, if present, shall be verified in the field prior to submitting. Submit drawings, markup, sketches, information, or other materials for documenting the following existing conditions:
  - 1. All I/O on PLC modules that have its wiring modified or new I/O terminated or for any PLC that is being decommissioned/removed/demolished. Document module number, point number, wire numbers, terminal numbers, destination, and function.
  - 2. All wiring entering or leaving a PLC that is being decommissioned, removed, or demolished that is not otherwise accounted for.
- B. When all information has been gathered, it shall be submitted to Engineer along with a clear and unequivocal statement that the existing conditions have been documented and understood. Contractor shall be held responsible for all issues that arise due to Contractor's modifications, demolition, removal, or decommissioning of existing equipment, including necessary reversion back to previous conditions.

### **1.04 DIGITAL HARDWARE SUBMITTALS**

- A. Submit system block diagram(s) showing:
  - 1. All equipment to be provided.
  - 2. All interconnecting cable.
  - 3. Equipment names, manufacturer, and model numbers.
  - 4. Equipment locations.
- B. Submit information for all digital equipment including, but not limited to, the following:
  - 1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.
  - 2. Catalog cuts, including complete part number breakdown information.
  - 3. Complete technical, material and environmental specifications.
  - 4. Assembly drawings.
  - 5. Mounting requirements.



6. Color samples.
7. Nameplates.
8. Environmental requirements during storage and operation.

#### **1.05 SOFTWARE SUBMITTALS**

A. Software submittals shall include the following as a minimum:

1. Bill of materials with software names, vendors, and complete listings of included software modules.
2. Standard manufacturer's literature describing the products.
3. Description of function of software in Control and Information System.
4. Limitations or constraints of software.
5. Minimum system (processor and memory) requirements.
6. Operation and maintenance requirements.

B. Submit information on the following software:

1. Third-party software, including:
  - a. Operating system.
  - b. Operator workstation (SCADA or HMI) software, including all add-in software provided to perform specific functions (alarm dialers, schedulers, backup creation software, etc.).
  - c. Office-type products, such as spreadsheets, word processors, etc.
  - d. Database management software.
  - e. Communication software, including all applicable local and wide area network software.
  - f. Programmable controller programming software (where applicable).
2. Software configuration, including:
  - a. Graphic display organization.
  - b. Database configuration for operator workstations and database management system.

- c. Trends.
- d. System security.
- e. Formats for all reports, including all required calculations.
- f. Intercommunications between software products required to implement system functions.
- g. Equipment backup configuration and requirements.

#### C. Control Strategies

1. Description of automatic logic and all non-standard manual logic using plain English, for non-technical persons, and written in Contractor's own words. The write-up shall include references to associated I/O, tag/loop numbers, alarming/interlocks.
2. Submitting language verbatim to Section 40 61 96 – Process Control Descriptions shall not be acceptable.

#### D. Application Software

1. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.
2. Application software includes all custom routines developed specifically for this project, or pre-written routines used for accomplishing specified functions for this project. This shall include any add-in custom software.

#### E. Graphic Displays

1. Submit all graphic displays required to perform the control and operator interface functions specified herein. Submitted graphic displays shall be for both new and modified graphics.
2. Submit the complete set of graphic displays for review by the Owner and the Engineer at least 60 days prior to commencement of factory testing.
3. Where a large number of graphic displays are required, submit an initial set of example displays for review before the complete set of displays is submitted. This initial set shall include examples of all basic graphic display design features and parameters and is intended to allow the Contractor to obtain preliminary approval of these features and parameters prior to beginning main graphic display production.

4. The Contractor shall allow for one major cycle of revisions to the displays prior to factory testing and one minor cycle of revisions following factory test. A cycle of revisions shall be defined as all revisions necessary to complete a single set of changes marked by the Engineer and the Owner. Additional corrections shall be performed during start-up as required to accommodate changes required by actual field conditions, at no additional cost to the Owner.
5. The required submittals in each revision cycle shall be full color prints of the entire set of displays.
6. Displays shall be printouts of actual process graphics implemented in the system.

#### **1.06 CONTROL PANEL SUBMITTALS**

- A. Submittals shall be provided for all control panels, and shall include:
  1. Exterior panel drawings with front and side views, to scale.
  2. Interior layout drawings showing the locations and sizes of all equipment and wiring mounted within the cabinet, to scale.
  3. Panel area reserved for cable access and conduit entry.
  4. Location plans showing each panel in its assigned location.
- B. Submit information for all exterior and interior panel mounted equipment including, but not limited to, the following:
  1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.
  2. Catalog cuts, including complete part number breakdown information.
  3. Complete technical, material and environmental specifications.
  4. Assembly drawings.
  5. Mounting requirements.
  6. Color samples.
  7. Nameplates.
  8. Environmental requirements during storage and operation.
- C. Submit panel wiring diagrams showing power, signal, and control wiring, including surge protection, relays, courtesy receptacles, lighting, wire size and color coding, etc.

## **1.07 INSTRUMENT SUBMITTALS**

- A. Submit information on all field instruments, including but not limited to the following:
  - 1. Product (item) name and tag number used herein and on the Contract Drawings.
  - 2. Catalog cuts, including complete part number breakdown information.
  - 3. Manufacturer's complete model number.
  - 4. Location of the device.
  - 5. Input output characteristics.
  - 6. Range, size, and graduations.
  - 7. Physical size with dimensions, NEMA enclosure classification, and mounting details.
  - 8. Materials of construction of all enclosures, wetted parts and major components.
  - 9. Instrument or control device sizing calculations where applicable.
  - 10. Certified calibration data on all flow metering devices.
  - 11. Environmental requirements during storage and operation.
  - 12. Associated surge protection devices.
  - 13. Installation drawings/details.

## **1.08 WIRING AND LOOP DIAGRAMS**

- A. Submit interconnection wiring and loop diagrams for all panels and signals in the Control and Information System.
- B. Electrical interconnection diagrams shall show all terminations of equipment, including terminations to equipment and controls furnished under other Divisions, complete with equipment and cable designations. Where applicable, interconnection wiring diagrams shall be organized by input/output card. Interconnecting diagrams shall be prepared in a neat and legible manner on 11 X 17-inch reproducible prints.
- C. Loop drawings shall conform to the latest version of ISA Standards and Recommended Practices for Instrumentation and Control. Loop Drawings shall conform to ISA S5.4, Figures 1-3, Minimum Required Items.

- D. Loop drawings shall not be required as a separate document provided that the interconnecting wiring diagrams required in Paragraph B., above, contain all information required by ISA 5.4.

## **1.09 OPERATION AND MAINTENANCE MANUALS**

- A. The Contractor shall deliver equipment operation and maintenance manuals in compliance with Section 01 33 00 – Submittals. Operation and maintenance (O&M) manuals shall consist of two basic parts:
  - 1. Manufacturer standard O&M manuals for all equipment and software furnished under this Division.
  - 2. Custom O&M information describing the specific configuration of equipment and software, and the operation and maintenance requirements for this particular project.
- B. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All modifications to manufacturer standard equipment and/or components shall be clearly identified and shown on the drawings and schematics. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.
- C. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operation and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include troubleshooting data and full preventive maintenance schedules. The instructions shall be bound in locking 3-D-ring binders with bindings no larger than 3.5 inches. The manuals shall include 15% spare space for the addition of future material. The instructions shall include drawings reduced or folded and shall provide the following as a minimum.
  - 1. A comprehensive index.
  - 2. A functional description of the entire system, with references to drawings and instructions.
  - 3. A complete "as built" set of all approved shop drawings, which shall reflect all work required to achieve final system acceptance.
  - 4. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data.
  - 5. Full specifications on each item.

6. Detailed service, maintenance, and operation instructions for each item supplied.
  7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
  8. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier.
  9. References to manufacturers' standard literature where applicable.
  10. Warning notes shall be located throughout the manual where such notes are required to prevent accidents or inadvertent misuse of equipment.
- D. The operating instructions shall clearly describe the step by step procedures that must be followed to implement all phases of all operating modes. The instructions shall be in terms understandable and usable by operating personnel and maintenance crews and shall be useful in the training of such personnel.
- E. The maintenance instructions shall describe the detailed preventive and corrective procedures required, including environmental requirements during equipment storage and system operation, to keep the System in good operating condition. All hardware maintenance documentation shall make reference to appropriate diagnostics, where applicable, and all necessary wiring diagrams, component drawings and PCB schematic drawings shall be included.
- F. The hardware maintenance documentation shall include, as a minimum, the following information:
1. Operation Information: This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.
  2. Preventive Maintenance Instructions: These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.
  3. Corrective Maintenance Instructions: These instructions shall include guides for locating malfunctions down to the card replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.
  4. Parts Information: This information shall include the identification of each replaceable or field repairable component. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross references between equipment numbers and manufacturer's part numbers shall be provided.

G. Software documentation shall conform to a standard format and shall include, but not be limited to, the following:

1. A program abstract that includes:
  - a. Program Name - The symbolic alphanumeric program name.
  - b. Program Title - English text identification.
  - c. Program Synopsis - A brief text shall be provided that specifies the need for the program, states when it shall be used and functionally describes all inputs, outputs and functions performed. This descriptive text shall be written in a language that is understandable by non-programming-oriented readers.
2. A program description that shall include, but not be limited to, the following:
  - a. Applicable Documents - List all documents (standard manufacturer's literature, other program descriptions, etc.) by section, if practical, that apply to the program. One complete copy of all applicable reference material shall be provided.
  - b. Input Output - Identify each input and output parameter, variable, and software element used by the program. State the purpose of all inputs, outputs, and variables.
  - c. Processing - This section shall contain a description of the overall structure and function of the program. Describe the program run stream and present a detailed description of how the program operates. Describe the timing and sequencing of operations of the program relative to other programs. Describe all interactions with other programs. Processing logic that is not readily described without considerable background information shall be handled as a special topic with references to an appendix or to control strategy document that details the necessary information. Reference shall also be made to an appendix or control strategy document for equation and program algorithm derivations.
  - d. System Configuration - Describe in detail the system configuration or status required for program implementation, if appropriate.
  - e. Limitations and Constraints - Summarize all known or anticipated limitations of the program, if appropriate.
  - f. Storage - Define program storage requirements in terms of disk or RAM memory allocation.

- g. Verification - Describe, as a minimum, a test that can be used by the operator to assure proper program operation. Define the required system configuration, input requirements and criteria for successful test completion.
- h. Diagnostics - Describe all program diagnostics, where applicable. Descriptions shall list each error statement, indicate clearly what it means, and specify what appropriate actions should be taken.
- i. Malfunction Procedures - Specify procedures to follow for recovering from a malfunction due to either operator error or other sources.

#### **1.10 FINAL SYSTEM DOCUMENTATION**

- A. All documentation shall be delivered to the Owner prior to final system acceptance in accordance with the Contract Documents. As a minimum, final documentation shall contain all information originally part of the control system submittals.
- B. Provide a complete set of detailed electrical interconnection diagrams required to define the complete instrumentation and control system. All diagrams shall be 11 X 17-inch original reproducible prints. All diagrams shall be corrected to describe final "as built" hardware configurations and to reflect the system configuration and control methodology adopted to achieve final system acceptance.
- C. Provide system software documentation for the operation and maintenance of all system software programs provided as a part of the digital system. All system software documentation shall be amended as required to delineate all modifications and to accurately reflect the final as built software configurations.
- D. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.
- E. Provide control strategy documentation which shall include control strategy (block oriented or ladder logic) diagrams to describe the control of all processes. Control strategy documentation shall reflect the system configuration and control methodology adopted to achieve final system acceptance. Control strategy documentation shall conform to the submittal requirements listed hereinabove.
- F. O&M documentation shall be amended with all final, adjusted values for all setpoints and other operating parameters for Owner reference.
- G. The Owner recognizes the fact that not all possible problems related to real time events, software interlocks, and hardware maintenance and utilization can be discovered during the Acceptance Tests. Therefore, the instrumentation subcontractor through the Contractor shall investigate, diagnose, repair, update, and distribute all pertaining documentation of the deficiencies that become evident during the warranty period. All



such documentation shall be submitted in writing to the Owner within 30 days of identifying and solving the problem.

### **1.11 PROGRAMS AND SOURCE LISTINGS**

- A. Provide one copy of all standard, off-the-shelf system and application software (exclusive of firmware resident software) on original media furnished by the software manufacturer.
- B. Provide one copy of source listings on digital media, acceptable to Engineer, for all custom software/logic written specifically for this facility, all database files configured for this facility, and all control strategies. All source listings shall include a program abstract, program linkage and input/output data. Comments describing the program flow shall be frequently interspersed throughout each listing.
- C. All software/logic shall be in both its native format and in Adobe Portable Document Format.

### **1.12 SUBMITTAL/DOCUMENTATION FORMAT**

- A. All drawing-type submittals and documentation shall be rendered and submitted in the latest version of AutoCAD.
- B. All textual-type submittals and documentation shall be rendered and submitted in the latest version of Microsoft Word or in searchable Adobe Portable Document Format (PDF). Raster scans will not be accepted.

### **1.13 ELECTRONIC O&M MANUALS**

- A. Subject to acceptance by the Engineer, the O&M information may be submitted in part or in whole in an electronic format on digital media.
- B. Electronic O&M manuals shall contain information in standard formats (searchable Adobe PDF, Word, AutoCAD, HTML, etc.) and shall be easily accessible using standard, "off-the-shelf" software such as an Internet browser. Raster scans will not be accepted.

## **PART 2 – PRODUCTS (NOT USED)**

## **PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

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**SECTION 40 61 21**  
**PROCESS CONTROL SYSTEM TESTING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall test the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21.71 – Factory Witness Test
- C. Section 40 61 21.72 – Field Testing
- D. Section 40 61 21.73 – Final Acceptance Test

**1.03 SUBMITTALS**

- A. For each of the specified tests, submit a test plan to the Engineer at least one month in advance of commencement of the tests. The test plan shall contain the following at a minimum:
  - 1. A schedule of all testing to be conducted.
  - 2. A brief description of the testing to be performed
  - 3. Test objectives.
  - 4. Testing criteria per the Specifications.
  - 5. Check lists and procedures for performing each of the specified tests.
  - 6. Sample test result documentation.
  - 7. Requirements for other parties.

**1.04 GENERAL REQUIREMENTS**

- A. All system start-up and test activities shall follow detailed test procedures; check lists, etc., previously approved by the Engineer. The Engineer shall be notified at least 21 days in advance of any system tests and reserves the right to have his and/or the Owner's representatives in attendance.

- B. The Contractor shall provide the services of experienced factory trained technicians, tools and equipment to field calibrate, test, inspect, and adjust all equipment in accordance with manufacturer's specifications and instructions.
- C. The Contractor (or designee) shall maintain master logbooks for each phase of installation, startup and testing activities specified herein. Each logbook shall include signal, loop or control strategy tag number, equipment identification, description and space for sign-off dates, Contractor signature and Engineer signature. Example test documentation specific to each phase of testing shall be approved prior to initiation of that testing, as specified hereinabove.
- D. All test data shall be recorded on test forms, previously approved by the Engineer. When each test has been successfully completed, a certified copy of all test results shall be furnished to the Engineer together with a clear and unequivocal statement that all specified test requirements have been met and that the system is operating in accordance with the Contract Documents.
- E. The Engineer will review test documentation in accordance with the Contract Documents and will give written notice of the acceptability of the tests within 10 days of receipt of the test results.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

**SECTION 40 61 21.71**  
**FACTORY WITNESS TEST**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall perform a Factory Witness Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21 – Process Control System Testing
- C. Section 40 61 21.72 – Field Testing
- D. Section 40 61 21.73 – Final Acceptance Test

**1.03 FACTORY WITNESS TEST**

- A. The Control and Information System equipment shall not be shipped until the Contractor receives notice of acceptability of the factory tests.
- B. Each item of equipment shall be fully factory inspected, calibrated and tested for function, operation and continuity of circuits. Exceptions shall be approved in writing by the Engineer.
- C. Each subsystem shall be fully factory tested for function and operation.
- D. System performance shall be tested using a fully integrated system, including all software and hardware. To achieve this, the entire control system, including all peripheral devices and all interconnecting cables (field instruments are not included in this requirement), shall be assembled on the factory test floor and the complete operational program loaded and simulated inputs applied.
- E. All hardware and software required to perform the specified testing shall be furnished by the Contractor at no additional cost to the Owner.
- F. The instrumentation subcontractor shall perform a 100-hour full system test, during which the entire system shall operate continuously without failure in accordance with the requirements of the Contract Documents. If a system component fails during the test, the 100-hour test period shall be restarted after its operation is restored.
- G. The factory testing shall demonstrate all aspects of system sizing and timing including:

1. Monitoring and control scan times at the PLC level.
  2. Response times at the operator workstation level.
- H. The overall system as well as individual component hardware shall be tested under conditions of power failure to ensure proper response as specified herein.
- I. Operator Workstation Operation - This demonstration shall provide proof of system operation on an individual subsystem basis first, and then in the expected operating environment. Both normal and abnormal operating modes shall be demonstrated. Operator workstation testing shall include the following:
1. Demonstrate proper operation, under both normal and abnormal conditions of the operator workstation application software (SCADA, remote alarm dial-up, etc.). This shall include demonstration of system on-line diagnostics, fail-over features, reconfiguration operations, system initialization and restart, software fault tolerance, error detection and recovery, communications, and all additional features necessary to assure the successful operation of the system.
  2. Demonstrate the standard features of the system. This shall include proof of operation of the process control database generator, the display generator, data storage and retrieval functions, data acquisition and control, trending functions, and reporting functions.
  3. Demonstrate the configuration of the system to verify conformance with the Contract Documents. This shall include graphic displays and vectoring, operator interface functions, trending, reports, alarm management, security system configuration, etc.
  4. The system shall be operated with data input/output with the PLCs and associated panels to prove operation of all workstation functions.
  5. The testing in Items 2 and 3 above may be performed concurrently (i.e., the standard and configured features of the system may be demonstrated simultaneously).
- J. PLC Operation - All functions comparable to those demonstrated for the operator workstations shall be demonstrated on the PLCs. This shall include the following:
1. On-line and off-line diagnostics.
  2. For redundant units, fail-over operation and reconfiguration.
  3. System initialization and restart.
  4. Network communications, including fieldbus communications where required.

5. Non-volatility of memory.
  6. Operation of all control logic shall be demonstrated as described herein.
- K. Process I/O Simulation - Process input/output simulation for PLCs shall be performed with a manual simulation control panel, a separate programmable logic controller, network-based simulation software, analog signal generators, and/or jumpering of discrete signals between outputs and associated inputs, or some combination of these. Alternate process I/O systems such as plug-in circuit cards or I/O test modules may be utilized subject to approval by the Engineer to provide the specified simulation functions. The simulation system shall provide analog and discrete I/O hardware devices in sufficient quantity to allow complete and thorough testing of the control strategies and functions of the system. The process I/O simulation system shall be used in several ways as follows:
1. To provide a means of communications checkout from the operator workstations through the various levels of software in the PLCs and to the process, i.e., the simulation panel. Likewise, a discrete or analog input shall be initiated from the simulation panel and the result monitored at the workstations.
  2. Alarm response to discrete status changes or analog value limits shall be verified. Database entries or attributes such as engineering units and conversion equations shall be verified by varying analog inputs.
  3. To provide data for use at all levels of the control system at the time of system integration.
- L. Control Strategy Testing - Provision shall be made to test all control strategies to prove the integrity of each strategy and the process control language in which it is implemented. For each control strategy, all functions shall be tested individually (where possible) and collectively to verify that the control strategy performs as described herein and as required for overall functionality within the control system.

## **PART 2 – PRODUCTS (NOT USED)**

## **PART 3 – EXECUTION (NOT USED)**

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**SECTION 40 61 21.72**  
**FIELD TESTING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall perform field testing on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21 – Process Control System Testing
- C. Section 40 61 21.71 – Factory Witness Test
- D. Section 40 61 21.73 – Final Acceptance Test
- E. Section 40 70 00 – Instrumentation for Process Systems

**1.03 GENERAL REQUIREMENTS**

- A. Control system start-up and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:
  - 1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified in Section 40 70 00 – Instrumentation for Process Systems.
  - 2. Each final control element shall be individually tested as specified hereinafter.
  - 3. Each control loop shall be tested as specified hereinafter.
  - 4. Each control strategy shall be tested under automatic digital control as specified hereinafter.
  - 5. The entire control system shall be tested for overall monitoring, control, communication, and information management functions, and demonstrated for system availability as specified hereinafter.
- B. System start-up and test activities shall include the use of water, if necessary, to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

- C. Each phase of testing shall be fully and successfully completed and all associated documentation submitted and approved prior to the next phase being started. Specific exceptions are allowed if written approval has been obtained in advance from the Engineer.

#### **1.04 CONTRACTOR'S RESPONSIBILITIES**

- A. The Contractor shall ensure that all mechanical equipment, equipment control panels, local control panels, field instrumentation, control system equipment and related equipment and/or systems are tested for proper installation, adjusted and calibrated on a loop-by-loop basis prior to control system startup to verify that each is ready to function as specified. Each test shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.
- B. The Contractor shall be responsible for coordination of meetings with all affected trades. A meeting shall be held each morning to review the day's test schedule with all affected trades. Similarly, a meeting shall be held each evening to review the day's test results and to review or revise the next day's test schedule as appropriate.
- C. The Contractor shall ensure that the electrical subcontractor conforms to the start-up, test and sign-off procedures specified herein to assure proper function and coordination of all motor control center control and interlock circuitry and the transmission of all discrete and/or analog signals between equipment furnished by the electrical subcontractor and the control system specified herein.
- D. The Contractor shall ensure that the HVAC subcontractor conforms to the start-up, test and sign-off procedures specified herein to assure proper function of all HVAC system control and interlock circuitry and the transmission of all discrete and/or analog signals between HVAC equipment and controls and the control system specified herein.

#### **1.05 FINAL CONTROL ELEMENT TESTING**

- A. The proper control of all final control elements shall be verified by tests conducted in accordance with the requirements specified herein.
- B. All modulating final control elements shall be tested for appropriate speed or position response by applying power and input demand signals and observing the equipment for proper direction and level of reaction. Each final control element shall be tested at 0, 25, 50, 75, and 100 percent of signal input level and the results checked against specified accuracy tolerances. Final control elements, such as VFDs, that require turndown limits shall be initially set during this test.
- C. All non-modulating final control elements shall be tested for appropriate position response by applying and simulating control signals and observing the equipment for proper reaction.

## **1.06 LOOP CHECKOUT**

- A. Prior to control system startup and testing, each monitoring and control loop shall be tested on an individual basis from the primary element to the final element, including the operator workstation or loop controller level, for continuity and for proper operation and calibration.
- B. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.
- C. The accuracy of all DACs shall be verified by manually entering engineering unit data values at the operator workstation and then reading and recording the resulting analog output data.
- D. The accuracy of all ADCs shall be verified using field inputs or by manually applying input signals at the final controller, and then reading and recording the resulting analog input data at the operator workstation.
- E. Each loop tested shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

## **1.07 CONTROL SYSTEM STARTUP AND TESTING**

- A. Control system startup and testing shall be performed to demonstrate complete compliance with all specified functional and operational requirements. Testing activities shall include the simulation of both normal and abnormal operating conditions.
- B. All digital hardware shall be fully inspected and tested for function, operation and continuity of circuits. All diagnostic programs shall be run to verify the proper operation of all digital equipment.
- C. Final control elements and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits.
- D. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses for final control elements. Simulated input data signals may be used subject to prior written approval by the Engineer.
- E. Each control strategy shall be tested to verify the proper operation of all required functions. The control system start-up and test activities shall include procedures for tuning all control loops incorporating PID control modules, and for adjusting and testing all control loops as required to verify specified performance.

- F. The control system start-up and test activities shall include running tests to prove that the Instrumentation, Control and Information System is capable of continuously, safely and reliably regulating processes, as required by the Contract, under service conditions that simulate, to the greatest extent possible, normal plant operating ranges and environmental conditions.
- G. A witnessed functional acceptance test shall be performed to demonstrate satisfactory performance of individual monitoring and control loops and control strategies. At least one test shall be performed to verify that the control and instrumentation system is capable of simultaneously implementing all specified operations.
- H. Each loop and control strategy test shall be witnessed and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

#### **1.08 FACILITY STARTUP COORDINATION**

- A. Facility start-up shall comply with requirements specified in the Contract Documents and those requirements specified herein. Facility start-up shall commence after all previously described start-up and test activities have been successfully completed and shall demonstrate that the Instrumentation, Control and Information System can meet all Contract requirements with equipment operating over full operating ranges under actual operating conditions.
- B. The control system start-up period shall be coordinated with process startup activities and shall be extended as required until all plant processes are fully operational and to satisfy the Engineer that all control system Contract requirements have been fulfilled in accordance with the Contract Documents.
- C. The instrumentation subcontractor's personnel shall be resident at the facility to provide both full time (eight hours/day, five days/week) and 24 hours on call (seven days/week) support of operating and maintenance activities for the duration of the start-up period.
- D. At least one qualified control systems technician shall be provided for control system startup and test activities and at least two when loop checkout is being performed.

#### **PART 2 – PRODUCTS (NOT USED)**

#### **PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

**SECTION 40 61 21.73  
FINAL ACCEPTANCE TEST**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall perform the Final Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21 – Process Control System Testing
- C. Section 40 61 21.71 – Factory Witness Test
- D. Section 40 61 21.72 – Field Testing

**1.03 AVAILABILITY DEMONSTRATION AND FINAL SYSTEM ACCEPTANCE**

- A. Upon completion of all control system startup activities and prior to final system acceptance, the Contractor shall demonstrate that the availability of the entire control system, including operation under conditions of digital equipment fail-over, initiated either automatically or manually, shall be not less than 99.8 percent during a 30-day availability test period. The Owner shall be given two (2) weeks' notice of the starting date of the 30-day availability test.
- B. For purposes of determining availability figures, downtime of each system or portions of each system resulting from the causes specified hereunder will not be considered system failures.
  - 1. Downtime of any network-connected device that is automatically backed-up upon failure shall not be considered a system failure provided that the downtime of the failed component does not exceed 24 hours.
  - 2. Downtime of a PLC that is not automatically backed-up shall be considered a system failure if the downtime of the failed controller exceeds one (1) hour.
  - 3. Downtime of a portion of the system resulting from failure of any field sensor shall not be considered a system failure provided that the system operates as specified under this condition.
  - 4. Downtime of the following devices shall not be considered a system failure provided the failed device is repaired within the specified time:

- a. Hard disc (one day)
  - b. Workstations (one day)
  - c. Communication interfaces (eight hours)
  - d. Printer (three days)
  - e. Process control system networks (eight hours)
  - f. Off-line (optical, etc.) storage units (one day)
  - g. UPS unit (one day)
5. Total shutdown of a single PLC resulting from a software fault shall be considered a system failure.
  6. An erroneous command to the process that can be specifically related to a software fault shall be considered as one (1) hour of downtime.
  7. The inoperability of any subsystem resulting from a software fault shall be considered a system failure.
  8. The failure of the same component more than one time during the 30-day test shall be considered a system failure.
- C. If the system fails the 30-day availability test, the 30-day test period shall be restarted after the failed component or software is repaired/replaced and full operation is restored. The system shall be demonstrated for the full 30-day period following the restart.
  - D. The Contractor shall submit an availability demonstration report that shall state that all system availability requirements have been met.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

**SECTION 40 61 22**  
**TOOLS, SUPPLIES, AND SPARE PARTS, GENERAL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall provide tools, supplies, and spare parts as specified herein for the operation and maintenance of the Control and Information System.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 33 00 – Submittals
- B. Section 40 61 13 – Process Control System General Provisions

**PART 2 – PRODUCTS**

**2.01 TOOLS**

- A. Provide special tools, other than those normally found in an electronic technician's tool box, required to test, diagnose, calibrate, install, wire, connect, disconnect, assemble and disassemble any digital equipment, instrument, panel, rack, cabinet or console mounted equipment for service and maintenance. This shall include, but not be limited to, the following: connector pin insertion and removal tools, wire crimping tools, special wrenches, special instrument calibrators, indicator lamp insertion and removal tools, etc.
- B. Provide tools and test equipment together with items such as instruction manuals, carrying/storage cases, unit battery charger where applicable, special tools, calibration fixtures, cord extenders, patch cords and test leads, which are not specified but are necessary for checking field operation of equipment supplied under this Division.
- C. One (1) Portable graphical multimeter with rechargeable battery, test leads, industrial lead set, and carrying case, Fluke Model 289, Simpson, or equal.
- D. Furnish one portable 4-20 mA, 24 VDC analog loop signal generator for calibration and testing of analog signal loops. Generator shall be furnished with rechargeable battery pack, test leads, spare battery pack, charger, carrying case and accessories. Signal generator shall be Fluke 787 ProcessMeter, or equal.
- E. Furnish one portable calibrator capable of measuring DC volts, mV, mA, ohms, frequency, T/C, peak detect and trip detect on its input and simultaneously generate on its output all of the preceding signals plus two-wire simulation, ramp functions, up/down stepping and 10 point programmability. The calibrator shall be furnished complete with 24 VDC integral battery pack, spare battery pack, test leads, external charger, fuse

pack, carrying case and appurtenances. It shall be possible to store and use automatic instrument calibration procedures that are downloaded from Windows-based instrument management software. Calibrator shall be Fluke 789 ProcessMeter, Ametek CL-9000, or equal.

- F. A complete computer technician kit in an injection molded or high density polyethylene case. The kit shall be Model JTK-49 Workstation Kit by Stanley Supply Services of Phoenix, AZ, or a computer technician kit of equivalent equipment and value.

## **2.02 SUPPLIES**

- A. The Contractor shall provide supplies as specifically required in other Sections of Division 40.

## **2.03 SPARE PARTS**

- A. Provide spare parts for items of control and instrumentation equipment as recommended by the manufacturer and in accordance with the Contract Documents.
- B. Furnish all spares in moisture-proof boxes designed to provide ample protection for their contents. Label all boxes to clearly identify contents and purpose.
- C. The Contractor shall replace all spare parts consumed during installation, testing, start-up, the system availability demonstration, and the guarantee period.
- D. Refer to individual digital hardware and instrument sections for additional requirements specific to those devices.

## **PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**



**SECTION 40 61 23**  
**SIGNAL COORDINATION REQUIREMENTS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall conform to the signal coordination requirements specified herein.
- B. The Contractor shall be responsible for coordinating signal types and transmission requirements between the various parties providing equipment under this Contract. This shall include, but not be limited to, distribution of appropriate shop drawings among the equipment suppliers, the electrical subcontractor, and the instrumentation subcontractor.
- C. Analog signals shall be signals for transmitting process variables, etc. from instruments and to and from panels, equipment PLCs and Control System PLCs.
- D. Discrete signals shall consist of contact closures or powered signals for transmitting status/alarm information and control commands between starters, panels, equipment PLCs, the Control System, etc.

**1.02 ANALOG SIGNAL TRANSMISSION**

- A. Signal transmission between electric or electronic instruments, controllers, and all equipment and control devices shall be individually isolated, linear 4-20 milliamperes and shall operate at 24 VDC.
- B. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating.
- C. All cable shields shall be grounded at one end only, at the control panel, with terminals bonded to the panel ground bus.
- D. Analog signal isolation and/or conversion shall be provided where necessary to interface with instrumentation, equipment controls, panels, and appurtenances.
- E. Non-standard transmission systems such as pulse duration, pulse rate, and voltage regulated shall not be permitted except where specifically noted in the Contract Documents. Where transmitters with nonstandard outputs do occur, their outputs shall be converted to an isolated, linear, 4-20 milliamperes signal.
- F. The Contractor shall provide 24 V power supplies for analog signals and instruments where applicable and as required inside panels, controls, etc.

- G. Where two-wire instruments transmit directly to the Control and Information System, the instrumentation subcontractor shall provide power supplies at the PLC-equipped control panels for those instruments.
- H. Where four-wire instruments with on-board loop power supplies transmit directly to the Control and Information System, the instrumentation subcontractor shall provide necessary signal isolators or shall otherwise isolate the input from the Control and Information System loop power supply. Similar provisions shall be made when a third element such as a recorder, indicator, or single loop controller with integral loop power supply is included in the loop.

### **1.03 DISCRETE INPUTS**

- A. All discrete inputs to equipment and Control and Information System PLCs, from field devices, starters, panels, etc., shall be unpowered (dry) contacts in the field device or equipment, powered from the PLCs, unless specified otherwise.
- B. Sensing power (wetting voltage) supplied by the PLC shall be 24 VDC.

### **1.04 DISCRETE OUTPUTS**

- A. All discrete outputs from local control panels and Control and Information System PLCs to field devices, starters, panels, etc., shall be dry contact relay outputs.
- B. PLC powered discrete outputs shall energize 24 VDC pilot relay coils in the field devices, starters, panels, etc. which in turn open or close contacts in the associated control circuit. The 24 VDC relay coil, contacts, and associated control circuitry shall be furnished integral with the field device, starter, panel, etc. by the supplier and contractor furnishing the field device, starter, or panel.
- C. Where required or specified herein, discrete outputs from equipment and Control and Information System PLC's to field devices, starters, panels, motor operated valves, etc., shall be dry contact or relay outputs.
- D. Outputs to solenoid valves shall be 120 VAC, powered from the PLC or control panel unless specified or shown otherwise.

### **1.05 OTHER DISCRETE SIGNALS**

- A. Discrete signals between starters, panels, etc. where no 24 VDC power supply is available may be 120 VAC, as long as such contacts are clearly identified in the starter, panel, etc. as being powered from a different power supply than other starter/panel components.
- B. Where applicable, warning signs shall be affixed inside the starter, panel, etc. stating that the panel is energized from multiple sources.

C. Output contacts in the starter, panel, etc., that are powered from other locations shall be provided with special tags and/or color-coding. Disconnecting terminal strips shall be provided for such contacts.

D. The above requirements shall apply to all starters and panels, regardless of supplier.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

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**SECTION 40 61 24**  
**QUALITY ASSURANCE**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. It is the intent of these Specifications and Drawings to secure high quality in all materials, equipment and workmanship in order to facilitate operations and maintenance of the facility. The Contractor shall provide equipment and services to meet this intent.

**1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS**

- A. All work shall be installed in accordance with the National Electric Code, National Electric Safety Code, OSHA, State, local and other applicable codes.

**1.03 QUALITY ASSURANCE - GENERAL**

- A. All equipment and materials shall be new and the products of reputable recognized suppliers having adequate experience in the manufacture of these particular items.
- B. For uniformity, only one manufacturer will be accepted for each type of product.
- C. All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses that may occur during fabrication, transportation, and erection as well as during continuous or intermittent operation. They shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.
- D. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, which shall be of sturdy and durable construction and be suitable for long, trouble-free service.
- E. Electronic components shall be de-rated to assure dependability and long-term stability.
- F. Printed circuit boards in field mounted equipment shall be suitable for the specified environmental conditions.
- G. Alignment and adjustments shall be non-critical, stable with temperature changes or aging and accomplished with premium grade potentiometers.
- H. Components of specially selected values shall not be inserted into standard electronic assemblies in order to meet the performance requirements of this specification.

#### **1.04 OPTIONAL EQUIPMENT**

- A. Optional or substituted equipment or both requiring changes in details or dimensions required to maintain all structural, mechanical, electrical, control, operating, maintenance or design features incorporated in these Specifications and Drawings shall be made at no additional cost to the Owner. In the event that the changes are necessary, calculations and drawings showing the proposed revisions shall be submitted for approval. The Contractor shall coordinate all changes with other affected trades and contracts and pay all additional charges incurred.

#### **1.05 GUARANTEE**

- A. The instrumentation subcontractor through the Contractor shall install, maintain and guarantee the Instrumentation, Control and Information System as specified under the General Conditions and Division 1 of the Specifications. Maintenance personnel provided by the instrumentation subcontractor shall instruct the Owner's personnel in the operation, adjustment, calibration and repair of the equipment being serviced. All preventive and corrective activities shall be documented with service reports, which shall identify the equipment being serviced, state the condition of the equipment, describe all work performed and list materials used. A copy of all service reports shall be delivered to the Owner on the day the work is performed.
- B. The instrumentation subcontractor shall provide the services of factory-trained service technician(s) at least twice during the guarantee period, for the purpose of performing preventive hardware maintenance.
- C. Corrective hardware and software maintenance during the guarantee period shall be performed in accordance with the requirements of Division 1 and, in addition, shall meet the following requirements:
  - 1. Corrective hardware maintenance shall be performed by factory-trained service technician(s) specifically trained to service the digital equipment provided. Technicians possessing suitable training and experience shall be provided to perform corrective maintenance on all other equipment. The hardware service technician(s) shall be available onsite within 24 working hours after notification by the Owner.
  - 2. Corrective software maintenance shall be performed for software provided by the instrumentation subcontractor and incorporated into the system prior to the completion of system commissioning. Software service programmer(s) shall be available for consultation within four business hours and, if required, on-site within 16 business hours after notification by the Owner. Corrective software maintenance shall include the supply, installation and startup of all application software upgrades released during the guarantee period.
  - 3. Corrective hardware and software maintenance performed during the guarantee period shall be performed at no cost to the Owner.

4. As used herein, the term "working hours" shall be defined as those of the treatment facility (seven days per week, 24 hours per day). The term "business hours" shall be defined as the hours between 8:00 a.m. and 5:00 p.m., local time, Monday through Friday; excluding holidays.
  5. The guarantee period shall commence upon final acceptance of the completed treatment facility in accordance with the provisions of the Contract Documents.
- D. The instrumentation subcontractor shall submit to the Owner a proposed maintenance agreement incorporating the following features:
1. Extension of preventive hardware maintenance services as described above for a period of up to five years from the expiration of the warranty period.
  2. Provisions for corrective hardware and/or software maintenance work on a will-call basis for a period of up to five years from the expiration of the warranty period. Corrective maintenance work shall be performed by properly trained personnel as described above.
- E. The proposed agreement shall include provisions for payment based upon an annual fee for preventive maintenance and cost plus expenses for corrective maintenance work. The portion dealing with corrective maintenance shall be written to include corrective maintenance caused by actions of the Owner during the warranty period and shall contain clauses for re-negotiation of contract prices based upon changes in recognized economic indicators published by the United States Department of Commerce.

#### **1.06 SHIPPING HANDLING AND STORAGE**

- A. In addition to shipping, handling and storage requirements specified elsewhere in the Contract Documents, air conditioning/heating shall be provided for storage of all field instrumentation, panels, digital equipment and ancillary devices to maintain temperatures between 20 and 25 degrees C and relative humidity 40 to 60 percent without condensation. The air shall be filtered and free of corrosive contaminants and moisture.

#### **1.07 FABRICATION**

- A. Fabrication of all equipment shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.
- B. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. The Contractor shall provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.

- C. Equipment approval at the factory only allows the equipment to be shipped to the project site. The Contractor shall provide for the proper storage, installation and satisfactory start-up and operation of the equipment to the satisfaction of the equipment manufacturer, the instrumentation subcontractor, and the Engineer.

## **1.08 INSTALLATION**

- A. All instrumentation and control system installation work, whether new construction or modifications to existing equipment/panels/structures, shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.
- B. The instrumentation subcontractor shall assign a competent representative who shall provide full time coordination and supervision of all on-site instrumentation and control system construction work from commencement of construction through completion and final acceptance.
- C. All labor shall be performed by qualified craftsmen in accordance with the standards of workmanship in their profession and shall have had a minimum of three years of documented experience on similar projects.
- D. All equipment and materials shall fit properly in their installations. Any required work to correct improperly fit installations shall be performed at no additional expense to the Owner.
- E. All work shall be performed in a neat and workmanlike manner. All hardware and instrumentation shall be installed in accordance with requirements specified herein, in accordance with industry best practices, in accordance with manufacturers' recommendations, and in a manner suitable for ease of operation, inspection, and maintenance. All wiring shall be neatly bundled, run in wireway, and terminated. All spare wiring shall be neatly coiled and clearly labeled at both ends for future use by the Owner. Any work not meeting these requirements shall be corrected at no expense to the Owner.
- F. Sufficient common-mode and differential-mode noise rejection shall be provided to ensure operation of the plant process control system to meet all specification requirements. General practice shall include:
  - 1. Maintaining crossings between noisy wires and signal wires at right angles.
  - 2. Maintaining separation between noisy wires and signal wires as wide as practical.
  - 3. Grounding all signals, shields and power supplies at the process control unit or local control panel.
  - 4. Providing passive filters on signals with time constant compatible with scan intervals and overvoltage protection.



5. Eliminating cable splices. All splices in instrumentation and control system signal and network cables shall be approved in advance by the Engineer.
  6. Providing a floating output for transmitters that have their own power sources.
- G. DC and AC power grounding shall be performed in accordance with the digital hardware manufacturer's recommendations as well as all applicable code requirements.
- H. The case of each field instrument and control panel shall be grounded in compliance with the National Electric Code.
- I. Power wires shall be separated from parallel running signal wires by the following minimum spacing:
- J. Circuit Voltage (VAC) Minimum Spacing (IN.)
1. 120VAC: 12in
  2. 240VAC: 18in
  3. 480VAC: 18in
  4. 2000VAC and above: 24in
- K. The Contractor shall provide all required cutting, drilling, inserts, supports, bolts, and anchors, and shall securely attach all equipment and materials to their supports. Embedded supports for equipment furnished under this Division shall be provided and installed as shown specified herein and shown on the Drawings.
- L. Following acceptance of the factory tests by the Engineer, and in accordance with the construction schedule, the Contractor shall commence installation of the digital control system hardware. Digital system equipment items shall not be installed, however, until all architectural, mechanical, HVAC and electrical work has been completed in the equipment rooms, MCC's, control rooms and all structural and/or mechanical work has been completed within 50 feet of equipment locations.
- M. Upon completion of the above construction work, the Contractor shall request an inspection of the above-named areas. The Engineer will issue a written approval to proceed with delivery and installation only after being satisfied that all work described above has been properly performed. Digital equipment shall remain at the factory site or storage prior to approval for delivery to the project site. Partial shipments may be required to meet construction schedule requirements.

## **PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

**SECTION 40 61 26**  
**PROCESS CONTROL SYSTEM TRAINING**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. To familiarize the Owner's personnel with the process control system and field instrumentation, training shall be provided as detailed hereunder.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions

**1.03 SUBMITTALS**

- A. A minimum of 60 days prior to beginning training, submit a detailed training plan describing the following:
  - 1. A listing of all courses to be conducted.
  - 2. Course content.
  - 3. Applicability of each course to management, operations, maintenance, laboratory, etc., personnel.
  - 4. Course schedules.
  - 5. Qualifications and experience of individual(s) providing training.
- B. A minimum of 14 days prior to beginning each training course, submit documentation for use by the Owner's personnel during training. The training documentation shall be specific to the particular course, and shall include the following:
  - 1. A listing of all subjects to be covered.
  - 2. Course schedule.
  - 3. Documentation/lesson plans covering all subjects to be covered during the course instruction. Information shall be in a "how to" format, with sufficient background documentation and references to manufacturer literature to provide a thorough and clear understanding of the materials to be covered.

**1.04 GENERAL REQUIREMENTS**

- A. All costs of providing the training courses shall be borne by the Contractor.

- B. As used herein, the term "day" shall mean an eight-hour day, and the term "week" shall mean a five-day, 40-hour week.
- C. Training courses, especially those for operator training, may be required to be scheduled during non-standard business hours (i.e., not between the hours of 8:00 am and 5:00 pm) to accommodate the working schedule of the Owner's personnel. No additional compensation will be awarded to the Contractor for training at non-standard hours.
- D. All training courses shall complement the experience and skill levels of the Owner's personnel.
- E. Training courses shall be structured in order of increasing capability or security levels. The purpose of this requirement is to allow personnel with lesser training requirements or security password levels to drop out of the training at certain times while the training continues for personnel with greater requirements or higher security levels.
- F. All training courses shall include lecture as well as "hands on" experience for each of the attending personnel. The Contractor shall provide sufficient equipment for this to be accomplished. For example, training in which the instructor uses the computer and the Owner's personnel passively observe as the instructor demonstrates system functions shall not be acceptable.
- G. Unless otherwise specified, all training courses shall be conducted in the Owner's facilities.
- H. All training shall be completed prior to system acceptance.
- I. Standard manufacturer training courses are acceptable pending approval by the Engineer and Owner.

#### **1.05 OPERATOR TRAINING**

- A. Two 2-day courses comprised of daily half-day (four-hour) sessions for up to ten persons each shall be conducted to provide instruction in the use of the Control and Information System to monitor and control the facility.
- B. Operator training shall include familiarization training covering the Control and Information System. Operators shall be instructed in the names, locations, functions, and basic operation of all items of digital equipment and associated software
- C. Operator training shall cover process and equipment operation both individually and collectively as an operating system. Normal as well as abnormal operating conditions shall be covered, including the response to failure occurrences and system alarms. All operator/system interactions shall be described.
- D. Operators shall be trained to instruct other operators and shall be provided with all course materials.

## **1.06 INSTRUMENT TRAINING**

- A. A one-day course shall be provided at the Owner's facilities no more than three months prior to system start-up to instruct a minimum of five persons each in the calibration and preventive maintenance of the field instruments provided under this Contract.

## **1.07 PLC TRAINING**

- A. A one-day course of specific training shall be provided by the instrumentation subcontractor in the use and modification of all control strategies provided under this Division.

## **1.08 GENERAL REFRESHER TRAINING**

- A. A two-day general refresher training course shall be provided for up to ten persons 3-6 months after final system acceptance. Instruction shall be given in all aspects of the complete instrumentation and control system. Instructor(s) shall be capable of answering questions related to all aspects and details of the complete system.

## **PART 2 – PRODUCTS (NOT USED)**

## **PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

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**SECTION 40 61 91**  
**PROCESS CONTROL SYSTEM INSTRUMENT LIST**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all instrumentation as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 90 – Schedules and Control Descriptions, General
- B. Section 40 61 93 – Process Control System Input/Output List
- C. Section 40 61 96 – Process Control Descriptions

**PART 2 – PRODUCTS**

**2.01 NAMEPLATES**

- A. Items of equipment listed in the instrument schedule, control panels, and digital hardware items shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include, as necessary, the equipment identification number, description, calibrated range, and set point(s). Abbreviations of the description shall be subject to the Engineer's approval.
- B. Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background. Nameplates attached to instruments may be black laser etched 1/8-inch high text on stainless steel with sharp edges made smooth. Stamped text shall not be acceptable.
- C. Nameplates shall be attached to metal equipment by NEMA rated stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of a braided stainless steel wire affixed with a permanent crimp.
- D. Submit sample nameplate of each type.

**PART 3 – INSTRUMENT SCHEDULE (SEE ATTACHED)**



## INSTRUMENT LIST

### Inline Magnetic Flow Meters - 40 71 13.13

Tag	Service Description	Range/Setpoint	Size	P&ID	Comment
FE-300	Pump Station Discharge Flow Tube	-	10 inch		

FIT-300 Pump Station Discharge Flow Transmitter -

### Level Switches (Floats) - 40 72 76.26

Tag	Service Description	Range/Setpoint	Size	P&ID	Comment
LSHH-251	Influent Channel High High Level Float Switch	-	-		

### Pressure Transmitters - 40 73 20

Tag	Service Description	Range/Setpoint	Size	P&ID	Comment
PIT-104	Pump Station Discharge Pressure Transmitter	-	-		

Single Point Gas Monitoring Systems - 40 76 21

Tag	Service Description	Range/Setpoint	Size	P&ID	Comment
AE-250A	Combustible Gas Detector Methane Sensor	-	-		
AE-250B	Combustible Gas Detector Petroleum Sensor	-	-		
AIT-250A	Combustible Gas Detector Methane Transmitter	-	-		
AIT-250B	Combustible Gas Detector Petroleum Transmitter	-	-		

**SECTION 40 61 93**  
**PROCESS CONTROL SYSTEM INPUT / OUTPUT LIST**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all control system inputs and outputs as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 90 – Schedules and Control Descriptions, General
- B. Section 40 61 91 – Process Control System Instrument List
- C. Section 40 61 96 – Process Control Descriptions

**PART 2 – CONTROL SYSTEM INPUT / OUTPUT SCHEDULE**

- 1. NOTES: Input/Output types are as follows:
  - a. DI – Discrete Input
  - b. DO – Discrete Output
  - c. AI – Analog Input
  - d. AO – Analog Output
  - e. RS485 – Serial Communications Link
- 2. All available information from each VFD via its RS485 port shall be provided to the PLC.

**PART 3 – SCHEDULE (SEE ATTACHED)**

**END OF SECTION**

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# CONTROL SYSTEM INPUT/OUTPUT LIST

SORTED BY NODE AND I/O TYPE

I/O Tag	Service Description	Function	PLC	I/O Type	P&ID	Comments
PI-104	Pump Station			AI		
LDI-201	Screenings Channel Differential Level			AI		
FI-300	Pump Station Discharge Flow			AI		
MAH-101	Pump 1 Seal Fail			DI		
TAH-101	Pump 1 High Temperature			DI		
YA-101	Pump 1			DI		
YL-101	Pump 1 Run			DI		
MAH-102	Pump 2 Seal Fail			DI		
TAH-102	Pump 2 High Temperature			DI		
YA-102	Pump 2			DI		
YL-102	Pump 2 Run			DI		
LAH-103	Pump Wetwell High Level			DI		
LAHH-103	Pump Wetwell High High Level			DI		
YA-105	PLC Fail Alarm			DI		
AAH-250A	Influent Channel High Methane Level			DI		
AAH-250B	Influent Channel High Petroleum Level			DI		
LAH-251	Influent Channel High Level			DI		
YA-900	Man Door Open			DI		

I/O Tag	Service Description	Function	PLC	I/O Type	P&ID	Comments
YA-901	Automatic Transfer Switch Loss of Utility Power			DI		
YA-902A	Generator Fault			DI		
YA-902B	Generator Low Fuel			DI		
YN-902	Generator Run			DI		
TAH-903	Electrical Room High Temperature Alarm			DI		

**SECTION 40 61 96**  
**PROCESS CONTROL DESCRIPTIONS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all equipment as herein specified and as shown on the Drawings. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING COMPLETE FUNCTIONING SYSTEMS AS DESCRIBED HEREIN.
- B. Together with the control system input/output schedule, the equipment specifications (including functional descriptions for local equipment control panels), and the Drawings, the functional control descriptions describe the required operation, monitoring, and control of the facilities included in this Contract.
- C. THE FUNCTIONAL DESCRIPTIONS CONTAIN REQUIREMENTS FOR FURNISHING AND INSTALLING LABOR AND MATERIALS THAT MAY NOT APPEAR ELSEWHERE IN THE CONTRACT DOCUMENTS.
- D. All equipment and services required in equipment local control panels provided to implement the monitoring and control functions described herein or in the process input/output schedules shall be provided by the Contractor through individual equipment suppliers.
- E. Unless specifically stated otherwise, all interconnected wiring between all instruments, panels, controls, and other devices listed in the functional descriptions as required to provide all functions specified herein shall be furnished by the electrical subcontractor under Division 26. The electrical subcontractor shall provide all cable and conduit required to carry all signals listed in the process input/output schedules. Special cables that are required for interconnection between sensors or probes and transmitters or signal conditioners shall be furnished with the instrumentation devices by the equipment supplier.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 01 92 10 – Maintenance of Utility Operations During Construction
- B. Section 40 61 90 – Schedules and Control Descriptions, General
- C. Section 40 61 91 – Process Control System Instrument List
- D. Section 40 61 93 – Process Control System Input/Output List

## **PART 2 – FUNCTIONAL CONTROL DESCRIPTIONS, GENERAL**

### **2.01 DEFINITIONS**

- A. RUNNING status signals shall be from auxiliary contacts provided with the motor control equipment (i.e., starter, VFD, SCR, etc.).
- B. AUTO status signals shall be defined as HAND-OFF-AUTO switch in the AUTO position or process control system in AUTO (versus MANUAL).
- C. FAIL status signals shall be defined as motor overload and/or any other shut down mode such as overtorque, overtemperature, low oil pressure, high vibration, etc.
- D. READY status signal shall be defined as all conditions, including equipment control power, satisfied to permit remote control of the equipment.

### **2.02 CONVENTIONS**

- A. Operator workstation graphic display symbols and indicator lights on all MCC's, control panels, starter enclosures, etc. shall conform to the following color convention:
  - 1. Running/On/Open: Red
  - 2. Auto/Ready: White
  - 3. Stopped/Off/Closed: Green
  - 4. Fail/Alarm: Amber
  - 5. Generic Status: White

### **2.03 PROCESS CONTROL**

- A. Where setpoints, operating limits, and other control settings are provided by the functional descriptions, these settings shall be initial settings only and shall be used for assistance in the initial startup of the plant. All such settings shall be fully adjustable and, based on actual operating conditions, the instrumentation subcontractor shall make all necessary adjustments to provide smooth, stable operation at no additional cost to the Owner.
- B. Provision shall be made in PLC logic to suppress nuisance alarms and control actions by the following means:
  - 1. For alarms and control actions derived from analog input signals, use adjustable time delays and deadbands.



2. For alarms and control actions derived from discrete input signals, use adjustable time delays.
  3. Initial settings for time delays shall be 10 seconds (range 0-120 seconds). Initial settings for deadbands shall be 5% of span (range 0-100%).
  4. Equipment that is started or stopped manually by the operator shall start or stop immediately, with no time delay.
- C. All setpoint control shall be by PID control algorithms. Where only proportional control is specified, tuning constants shall be used to reduce the Integral and Derivative functions to zero. All setpoints, sequence times, sequence orders, dead bands, PID tuning parameters, PLC delay timers, variable speed operating range limits, and similar control constants shall be accessible and alterable from the operator workstations.
- D. Unless otherwise specified, all equipment shall automatically restart after a power failure utilizing adjustable start delay timers in PLC control logic. Unless otherwise specified, all PLC control strategies shall be based upon automatic restart after a power failure and shall return to a normal control mode upon restoration of power.
- E. The PLC shall be capable of receiving initial run-time values for existing and proposed equipment. Initial run-time shall not automatically be assumed to be zero.
- F. A control discrepancy alarm shall be generated through the PLC for any drive, motor, etc. for which a command has been issued, but for which the PLC is not receiving a confirming status signal (e.g., start command with no run feedback). The failure shall be logged.
- G. An instrument failure alarm shall be generated for any instrument which is generating a signal that is less than 4 mA or greater than 20 mA.
- H. Unless otherwise specified in an individual control description, an instrument failure or control discrepancy alarm shall cause the control strategy to maintain last values and to generate an alarm. Manual initiation of the automatic control strategy shall be required.
- I. A control program that controls multiple pieces of equipment shall not be prevented from running because not all of the equipment is in AUTO. If equipment within an equipment chain is required to be running for program operation and it is running in HAND or MANUAL, then the program shall run and control the other equipment that is in AUTO.
- J. All PLC wait states (internal time delays, etc.) after an operator action shall be displayed on the operator workstation.

## **PART 3 – FUNCTIONAL CONTROL DESCRIPTIONS**

### **3.01 INFLUENT SCREENING**

## A. Process Overview

A mechanical screen provided under Section 46 21 13 shall under normal circumstances run continuously to screen influent prior to being pumped to the sanitary sewer manhole. A screenings transporter provided with the screen shall operate in coordination with the screen to carry screenings to the dumpster.

## B. Control Operation

A factory control panel controls the mechanical screen based on level in the influent channel. The same factory control panel operates the transporter to run in conjunction with the mechanical screen and for an adjustable length of time after the screen stops.

1. Differential level is measured across the screen by an ultrasonic level measurement system provided under Section 46 21 13. The differential level transmitter provides a 4-20 mA analog signal linear to differential level to the screen factory control panel.
2. The factory control panel shall transmit a 4-20 mA analog signal linear to differential level across the screen to the plant control system for remote indication. The plant control system shall generate a high differential level alarm for remote alarm.
3. Differential level setpoints shall be determined during startup.
4. The factory control panel shall provide discrete inputs to the PLC for remote indication and alarm for the following:
  - a. Screen Running Fast
  - b. Screen Running Slow
  - c. Screen Fail
  - d. Screen Emergency Stopped
  - e. Screen Overcurrent
  - f. Screenings Conveyor Running
  - g. Screenings Conveyor Fail
  - h. Screenings Conveyor Overcurrent
  - i. Screenings Conveyor Emergency Stopped

5. A high level float switch provided under this Division in the influent channel to the screenings structure shall provide a discrete input to the plant control system for a remote High Level alarm.

### **3.02 INFLUENT COMBUSTIBLE GAS DETECTION**

- A. Combustible gas monitors in the screenings structure influent channel provided under this Division shall monitor the levels of methane and petroleum gases in the influent screenings channel.
  1. Methane and petroleum gas sensors in the screenings channel shall each provide a signal to an associated transmitter for local indication of combustible gas levels. The transmitters shall transmit discrete signals for High levels of methane and/or petroleum to the plant control system for remote alarm.

### **3.03 PUMPS**

- A. Process Overview
  1. Two submersible pumps shall be provided under Section 43 25 13. The pumps shall be provided with a factory control panel and shall operate as a duplex pump station.
- B. Control Operations
  1. A multi-point level switch shall be provided by the pump supplier to control the pumps based on level in the wetwell as described in Section 43 25 13.
  2. High and low level float switches shall be provided by the pump supplier as backup level control as described in Section 43 25 13.
  3. The pump factory control panel shall provide discrete outputs to the PLC as follows:
    - a. Pump 1 Running
    - b. Pump 1 Fail
    - c. Pump 1 High Temperature
    - d. Pump 1 Leak
    - e. Pump 2 Running
    - f. Pump 2 Fail
    - g. Pump 2 High Temperature

- h. Pump 2 Leak
  - i. High Wetwell Level
  - j. High High Wetwell Level
  - k. Pump PLC Fail
4. Discharge pressure for the influent pumps common discharge header pressure shall be measured by PIT-104 provided under Section 40 73 20. The transmitter shall provide a 4-20 mA analog signal linear to pressure to the plant control system for remote indication.
5. Flow from the influent pump station shall be measured by FE/FIT-300 provided under Section 40 71 13.13,. The transmitter shall provide a 4-20 mA analog signal linear to flow to the plant control system for remote indication.

**END OF SECTION**

**SECTION 40 62 00**  
**COMPUTER SYSTEM HARDWARE AND ANCILLARIES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The process control system is physically and functionally distributed between PLC equipped control panels, motor control panels, field panels, operator workstations and appurtenances.
- B. Although manual control facilities shall be provided adjacent to each final control element or in local control panels, such facilities are for testing, maintenance and local monitoring purposes only and shall not be regarded as backup to the PLC-based control system.
- C. PLCs may be categorized as either “process PLCs” or “integration PLCs” that are provided by the instrumentation subcontractor or “equipment control PLCs” or “vendor PLCs” or “packaged PLCs” provided by equipment manufacturers for the operation of their equipment (blowers, centrifuges, chemical systems, filters, etc.). Unless otherwise specified, all PLCs provided under this Contract shall conform to the requirements specified in this Division.
- D. Major plant control system digital equipment items are described in the Specifications and shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 63 43 – Programmable Logic Controllers
- B. Section 40 62 16 – Operator Workstation Computers
- C. Section 40 66 00 – Network and Communication Equipment

**1.03 DIGITAL HARDWARE CONFIGURATIONS**

- A. The digital hardware configuration shown on the Drawing depicts overall system configuration requirements. System design shall be based upon this concept and shall provide an overall digital system availability of 99.8 percent under the conditions specified in Section 40 61 21.73 – Final Acceptance Test. Unless otherwise specified, designs that vary from this concept will be rejected.
- B. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level. Run time and flow accumulations shall be performed at the PLC level. Except for minimal calculations related to report-specific functions such as minimum, maximum, average, etc., operator workstations shall not be

used to perform calculation for the process control system. Operator workstations shall be fully independent devices, individually connected to the plant control system networks.

- C. No other exceptions will be considered.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL SYSTEM HARDWARE REQUIREMENTS**

- A. Unless otherwise specified, all hardware shall be rated for industrial use, resistant to shock, vibration, electromagnetic interference, static discharge, and suitable for the environmental conditions described elsewhere in this Division. Commercial or office grade equipment shall not be accepted.
- B. Unless otherwise specified, modular construction shall be employed to simplify maintenance and to provide for future hardware expansion. Plug-in, modular PCB's or modules shall be employed for easy removal to permit exposure of circuit wiring, components and test points. Extender boards shall be provided, if necessary, to permit PCB's to be completely exposed for testing purposes.
- C. Keying schemes shall be used to prevent PCB misplacement.
- D. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall activate a fan and generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature.

### **2.02 DIGITAL SYSTEM FAILURE DETECTION AND FAIL-OVER REQUIREMENTS**

- A. No degradation in control system performance shall occur when the system is operating in a partial failure or an equipment fail-over mode. Likewise, no degradation of system performance shall occur while a backed-up system component is undergoing preventive or corrective maintenance.
- B. All devices connected to the plant control system network shall be self-checking and shall report their operational status to the operator workstations as either "normal" or "failed". A graphic display based on the system architecture drawing shall be furnished with the control and information system showing this information along with current communication status of each device.

**PART 3 – EXECUTION**

**3.01 REQUIREMENTS**

- A. Refer to Section 40 61 13 – Process Control System General Provisions, Part 3.

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**SECTION 40 62 63**  
**OPERATOR INTERFACE TERMINALS (OIT)**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all operator interface units, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 62 00 – Computer System Hardware and Ancillaries
- C. Section 40 63 43 – Programmable Logic Controllers

**PART 2 – PRODUCTS**

**2.01 OPERATOR INTERFACE UNIT – LARGE**

- A. An Operator Interface Unit (OIU) shall be provided to view and change PLC monitoring and control parameters and to display alarm messages using a graphical user interface. The OIU shall provide the following features as a minimum:
  - 1. Minimum of 10.4 inch diagonal display
  - 2. 18-bit color TFT LCD 800 x 600 SVGA display
  - 3. Backlit analog resistive touch screen interface w/ 1 million press actuation rating
  - 4. Backlight w/ min. 50,000 hour life to half brightness
  - 5. Minimum of 512 MB internal storage
  - 6. Minimum of 512 MB RAM application memory
  - 7. Minimum of 80 MB nonvolatile user memory
  - 8. Windows CE Operating System
  - 9. Battery-backed real-time clock
  - 10. Secure Digital (SD) card slot w/ min. 2 GB card

11. One USB 2.0 high-speed Type A host port; one USB 1.0 high-speed Type B device port
  12. One 10/100Base-T Auto MDI/MDI-X Ethernet port
  13. Windows-based configuration software complete with download cable
  14. Operating Voltage: 120 VAC or 24 VDC (internal or via independent power supply)
  15. Enclosure Rating: NEMA 12/4X to match the associated PLC cabinet rating
  16. Environment: 0-55°C, 5-95% relative humidity, non-condensing
- B. The operator interface unit shall be Allen-Bradley PanelView Plus 7 Standard 1000, or equal.

## **2.02 OPERATOR INTERFACE UNIT – SMALL**

- A. An Operator Interface Unit (OIU) shall be provided to view and change PLC monitoring and control parameters and to display alarm messages using a graphical user interface. The OIU shall provide the following features as a minimum.
1. Minimum of 6.5 inch diagonal display
  2. 18-bit color TFT LCD 640 x 480 VGA display
  3. Backlit analog resistive touch screen interface w/ 1 million press actuation rating
  4. Backlight w/ min. 50,000 hr life to half brightness
  5. Minimum of 512 MB internal storage
  6. Minimum of 512 MB RAM application memory
  7. Minimum of 80 MB nonvolatile user memory
  8. Windows CE Operating System
  9. Battery-backed real-time clock
  10. Secure Digital (SD) card slot w/ min. 2 GB card
  11. One USB 2.0 high-speed Type A host port; one USB 1.0 high-speed Type B device port
  12. One 10/100Base-T Auto MDI/MDI-X Ethernet port
  13. Windows-based configuration software complete with download cable

14. Operating Voltage: 120 VAC or 24 VDC (internal or via independent power supply)
  15. Enclosure Rating: NEMA 12/4X to match the associated PLC cabinet rating
  16. Environment: 0-55°C, 5-95% relative humidity, non-condensing
- B. The operator interface unit shall be Allen-Bradley PanelView Plus 7 Standard 700, or equal.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. The OIU shall be configured to display all PLC I/O, setpoints, and parameters. All equipment failures shall be alarmed. PLC I/O values and operator-entered setpoints shall be displayed with associated units and service descriptions. Menus shall be provided to navigate between screens of different equipment items. Displays shall be arranged in a hierarchical structure with displays for specific equipment items grouped together. Additional functionality shall be as specified elsewhere in this Division.
- B. All necessary configuration and programming software shall be provided on optical media and turned over to the Owner.
- C. Unless otherwise indicated, each OIU shall be mounted between 48 and 60 inches above the floor or work platform.
- D. Refer to Section 40 61 13 – Process Control System General Provisions, for additional requirements.

**END OF SECTION**

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**SECTION 40 63 43**  
**PROGRAMMABLE LOGIC CONTROLLERS (PLC)**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all programmable logic controllers (PLC), with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 23 – Signal Coordination Requirements
- C. Section 40 62 00 – Control and Information System Hardware - General
- D. Section 40 62 63 – Operator Interface Units
- E. Section 40 66 00 – Process Control System Networks
- F. Section 40 67 63 – Uninterruptible Power Systems
- G. Section 40 67 00 – Control System Equipment Panels and Racks

**1.03 TOOLS, SUPPLIES AND SPARE PARTS**

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts. In addition, the following specific spare parts items shall be provided:
  - 1. One of each type and size of module for PLC equipment furnished under this Contract.
  - 2. One of each type and size of PLC and equipment power supply furnished under this Contract.

**PART 2 – PRODUCTS**

**2.01 PROGRAMMABLE LOGIC CONTROLLERS - GENERAL**

- A. The instrumentation subcontractor shall furnish programmable controllers (PLCs) as specified herein and as shown on the Drawings. PLCs shall be provided complete with backplane, power supply, I/O cards, special function cards, instructions, memory,

input/output capacity, and appurtenances to provide all features and functions as described herein. No substitutions will be permitted.

- B. All components of the PLC system shall be of the same manufacturer; who shall have fully tested units similar to those being furnished in an industrial environment with associated electrical noise. The PLC system shall have been tested to meet the requirements of NEMA Standard ICS 2-230 (Arc Test) and IEEE C37.90.1 (SWC). The processing unit shall perform the operations functionally described herein based on the program stored in memory and the status of the inputs and outputs.
- C. Programmable controllers shall be designed to operate in an industrial environment. The PLC shall operate in an ambient temperature range of 0°-60°C and a relative humidity of 5-95 percent, non-condensing. The PLC shall operate on supply voltages of 90-132 VAC at 47-63 Hz or 24 VDC if provided with a battery backup system. An integral fuse shall be provided on the power supply for short circuit protection and shall be front panel accessible. Integral overcurrent and undervoltage protection shall be provided on the power supply.
- D. Where applicable, the minimum PLC backplane size shall be 7 slots, not including power supply slots.
- E. System configuration shall be as shown on the Control System Architecture Drawing. PLC types shall be designated on the Control System Architecture Drawing and correspond to the specifications herein. Only a single type of processor shall be supplied for all PLCs of a designated type. Memory and processor shall be adequate for all control functions specified. PLCs shall be as manufactured or equal to the following:
  - 1. Allen-Bradley ControlLogix
  - 2. Allen-Bradley MicroLogix

## **2.02 PROCESSORS**

- A. The processor and its associated memory shall be enclosed in a modular enclosure. A multiple-position selector switch or equivalent shall be used to select processor operating mode. LED-type indicating lights shall be provided to indicate processor, memory, and battery status. Errors in memory shall be recognized and shall activate the memory error indicating lights. The PLC processor shall monitor the internal operation of the PLC for failure and provide an alarm output. Nonvolatile memory in the form of a manufacturer supplied industrial CompactFlash card or equivalent technology shall be required to maintain the entire current program and firmware of the controller in the event of power loss. The program shall be updated onto the flash memory each time a program change such as an online edit or tag value is changed. When nonvolatile memory (flash memory) is not available for certain controller models as offered by the PLC manufacturer, lithium batteries shall be used to maintain process RAM memory for at least one year in the event of power loss. The lithium battery unit shall be an

externally mounted battery assembly with the highest available capacity. The PLC shall send an alarm to the plant control system if battery level is low.

- B. The instruction set for the PLC shall conform to the requirements of IEC 61131-3. Each PLC shall have the capability to run all five of the standard IEC 61131-3 languages simultaneously. These five languages shall be:
  - 1. Ladder Diagram
  - 2. Structured Text
  - 3. Instruction List
  - 4. Function Block Diagram
  - 5. Sequential Function Chart
- C. Additional co-processors or modules may be necessary and shall be furnished as required to meet the functions specified herein and in Section 40 61 96 – Process Control Descriptions.
- D. PLC processors shall be provided with substantial user program, data and logic memory to allow for future expansion of the overall system. The total memory used on each processor shall be less than 60% of available memory at project completion.

### **2.03 COMMUNICATIONS**

- A. PLC communications shall be provided as specified in Section 40 66 00 – Process Control System Networks and as shown on the Control System Architecture Drawing.
- B. In addition to a communications port for the control system network, communication ports shall be provided for any other devices required (i.e., operator interface unit) plus an additional communication port for connection to a notebook computer.
- C. The PLC shall be able to support various types of fieldbus communication systems for data links to field instruments (where specified) in addition to connected equipment such as power monitors, VFDs, motor protection monitors, etc. As a minimum, Profibus DP, Foundation Fieldbus, Modbus RTU Master and Slave, TCP/IP Ethernet shall be supported. The Contractor shall coordinate the efforts of the necessary parties (instrumentation subcontractor and equipment suppliers) to accomplish the required device and data table addressing between each PLC and the associated connected equipment.
- D. Additional communication modules or protocol gateways may be required to support specific communication protocols required under this Contract and shall be supplied at no extra cost to the Owner.

## 2.04 INPUT/OUTPUT SUBSYSTEMS

- A. Input/output hardware shall be plug-in modules in associated I/O backplane/chassis or DIN-rail mounting assemblies. Each unit shall handle the required number of process inputs and outputs plus a minimum of 10 percent active pre-wired spares for each I/O type furnished, plus a minimum of 20 percent spare I/O module space for the addition of future circuit cards or modules.
- B. Discrete inputs shall be 24 VDC or 120 VAC signals (integral to the PLC) from dry field contacts. Discrete outputs shall be 24 VDC or 120 VAC outputs sourced from the PLC, or dry relay contacts (2A minimum) as required. Refer to Section 40 61 23 – Signal Coordination Requirements for further details of discrete signal type and voltage requirements. The PLC shall provide momentary and latched outputs as required to interface with motor controls and external devices. Interposing relays shall be provided where required to interface with field equipment. Interposing relays shall be as specified in Section 40 78 00. Electrical isolation shall be provided where required. Maximum density for discrete I/O modules shall be 32 per input module and 16 per output module.
- C. Analog input circuits shall be isolated, minimum 16-bit resolution type. Analog input hardware shall be provided as required for all types of analog inputs being transmitted to the PLC. In general, analog input modules shall be capable of receiving 4-20 mA signals. Where required, RTD input modules shall have a minimum resolution of 0.15°C and be capable of accepting signals from 100-ohm Platinum RTDs. Analog outputs shall be coordinated with the receivers but shall generally be isolated 24 VDC 4-20 mA outputs powered from the PLC. Each input/output circuit shall have optical isolation to protect the equipment against high voltage transients. Optical isolation shall be rated at not less than 1500 V RMS. Lightning/surge protection shall be provided as specified in Section 40 78 56 – Isolators, Intrinsically-Safe Barriers, and Surge Suppressors. Maximum density for analog I/O modules shall be 8 per module.
- D. Input/output modules shall be configured for ease of wiring and maintenance. The modules shall be connected to wiring arms that can be disconnected to permit removal of a module without disturbing field wiring. Covers shall be provided to prevent operator personnel from inadvertently touching the terminals. The process interface modules shall be provided with screw-type terminal blocks with barriers between adjacent terminals for connection of field inputs. Terminals shall be suitable for accepting up to and including No. 14 AWG wire. All DC output circuits to the field shall include fuses, either integral or at the terminal strip. Output failure mode shall be selectable so that upon station or communication system failure all outputs shall be placed either in the non-conducting mode or remain as were prior to failure. Light-emitting diodes shall be provided for status indication for each input and output point.
- E. External power supplies shall be provided with the PLC as required to meet specified installed I/O power requirements plus spares. Power supplies shall be modular units, shall be fully redundant and shall alarm the PLC upon failure. Power supplies shall have



a line regulation of 0.05% and meet the environmental and power requirements specified herein for the PLC.

## **2.05 REMOTE I/O SUBSYSTEMS**

- A. Remote I/O shall be provided as designated on the Control System Architecture Drawing. Remote I/O shall be either PLC backplane type I/O or field modules as manufactured by the PLC manufacturer. Field modules shall meet the requirements of Subsection 2.04, Input/Output Subsystems. Remote I/O processor or communication modules shall be modular and individually replaceable.
- B. Remote I/O shall communicate with the PLC using the PLC manufacturer's standard protocol or an open standard network such as DeviceNet, Ethernet IP, ProfiNet, Foundation Fieldbus, Modbus TCP/IP, or equal.

## **2.06 INPUT/OUTPUT CIRCUIT ARRANGEMENT**

- A. Signal and control circuitry to individual input/output boards shall be arranged such that board failure shall not disable more than one half of the control loops within any group of controlled equipment (e.g., one pump out of a group of three pumps, two pumps out of four, etc.). Where possible, individual control loops and equipment shall be assigned to individual boards such that failure of the board will disable only one loop or piece of equipment.

## **2.07 PROGRAMMING SOFTWARE**

- A. The PLC programming and configuration software shall be the manufacturer's latest, full-featured version, Windows-based, and shall be fully compliant with IEC 61131-3 standards. The software package shall consist of all programming, configuration, and documentation software needed to place the control and information system in satisfactory operation. The software shall allow on-line and off-line program development and documentation. PLC programming software shall include documentation on optical media.
- B. A minimum of one copy of the PLC programming software shall be purchased by the instrumentation subcontractor and registered to the Owner.
- C. All configuration and programming software necessary shall be provided on the computer specified in Section 40 62 26 – Laptop Computers for connection to the PLC processor via a communications port. All necessary hardware required to allow the notebook computer to perform PLC configuration and programming shall be provided.
- D. If available, the configuration and programming software shall support communication over the network specified in Section 40 66 00 – Network and Communication Equipment to implement its functions remotely from an operator workstation. All configuration and programming software necessary to implement this functionality shall be provided on the HMI Server operator workstations specified in Section 40 62 16 –

Operator Workstation Computers. All necessary hardware required to have the operator workstation perform PLC configuration and programming shall be provided.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. PLC programming shall be furnished to perform all functions described in Section 40 61 96 – Process Control Descriptions, including global functions. In addition, PLCs shall be programmed to provide additional functions described in other sections of this Division.
- B. PLC programming shall make use of the various IEC languages as appropriate to the specific task and shall be performed in a modular style making extensive use of program blocks (subroutines) and program variables to be passed to the program blocks for specific equipment. It is the intent of this requirement to allow for enhanced readability and ease of modification of the program code through the elimination of multiple instances of repeated code for the same function in a “hard-coded” style.
- C. Extensive comments shall be placed in the program code to describe the functions of all elements of the program code. PLC code that does not contain comments shall be rejected.
- D. Refer to Section 40 61 13 – Process Control System General Provisions, Part 3 for additional requirements.

### **3.02 REQUIREMENTS FOR MANUFACTURER-SUPPLIED PLCS**

- A. PLCs that are supplied for equipment local control panels by individual equipment manufacturers or suppliers shall, where so indicated on the Control System Architecture Drawing, be integrated into the plant control system. The manufacturer-supplied PLC shall be furnished, installed and programmed by the manufacturer. The PLC shall continuously monitor and control the associated system and at the same time shall provide all the required alarms, indications of system parameters, equipment status, etc. to the main control system at the plant.
- B. Where required as described above, each manufacturer-supplied PLC shall be connected to the Ethernet process control network for access from the plant control system HMI servers, as specified in Section 40 66 00 – Network and Communication Equipment, and shall contain a fiber optic Ethernet switch identical to those provided for the rest of the network-connected PLCs.
- C. Each equipment manufacturer shall provide all monitoring and control data to be transferred between the PLC and the plant control system in contiguous blocks of PLC registers to facilitate block read and write commands for efficient scanning by the control system SCADA servers. These contiguous registers shall be arranged in a single data transfer area, which shall be divided into eight distinct areas with an emphasis on

flexibility and future expansion. The distinct areas shall be arranged by data type (analog or discrete), transfer direction (server to PLC or PLC to server), and, where applicable, implementation schedule (current or future). Where required, peer-to-peer communication between PLCs shall likewise be accomplished using separate blocks of contiguous registers. Where individual equipment PLCs are not required to be connected to the plant control system via the data highway network, they shall provide the individual hardwired signals as specified in the Contract Documents. Data and commands for connection to the control system are described in the Drawings, the Input/Output Schedule, the individual equipment specification sections, and in Section 40 61 96 – Process Control Descriptions.

- D. The operator interface for control of each individual system shall be performed by local operator interface units as specified in Section 40 62 63 – Operator Interface Terminals or individual pilot devices on the equipment local control panel, as specified in the associated equipment specification section. Additional operator interface functions shall be provided through the plant control system as specified in the respective equipment specifications and in Section 40 61 96 – Process Control Descriptions.
- E. Where operator interface and control functions are required to be provided through the plant control system, the individual system supplier shall be responsible for coordination with the instrumentation subcontractor to provide a complete and working equipment control system. The individual equipment supplier shall also be responsible for limiting the access of the plant control system to the equipment PLC code so as to prevent malfunctions of the equipment and any failure to continuously perform its intended functions. The equipment supplier shall be responsible for ensuring that no actions by the plant control system can damage or otherwise adversely affect the operation of the associated equipment or the safety of personnel working on or near that equipment. The equipment supplier shall also provide direction in the configuration of the SCADA software's security system by the instrumentation subcontractor to limit access to the control functions of the equipment control system to authorized personnel only. The equipment supplier shall coordinate testing of the completed system with the instrumentation subcontractor, which shall conform to the requirements of Section 40 61 21.72 – Field Testing.
- F. The Contractor, equipment supplier and instrumentation subcontractor shall coordinate testing and startup of the equipment provided by the equipment supplier with the plant control system, including but not limited to the following tasks:
  - 1. Provide assistance with control system testing of inputs, outputs, and control strategies as needed.
  - 2. Provide support or interface work necessary to perform physical checkout and field testing to the final field devices. The schedule may require the instrumentation subcontractor and equipment manufacturer personnel to perform loop checks simultaneously, as directed by the Engineer.

3. Coordinate and assist as needed to maintain I/O connectivity throughout the system.
4. Ensure personnel safety while equipment is exercised via the plant control system.
5. Ensure that process, instrumentation, and control equipment are not damaged while equipment is exercised via the plant control system.
6. Provide temporary modifications to field devices and their terminations, if needed.
7. Providing labor and supervision, which may include, but is not limited to, the following: electricians, instrument technicians, manufacturer's representatives, and individual(s) knowledgeable about process startup and operation.
8. Operation of process equipment for verification of each plant control system input and output.

**END OF SECTION**

**SECTION 40 66 00**  
**PROCESS CONTROL SYSTEM NETWORKS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation IEEE 802.3 Ethernet local area network(s) for communications among plant devices.
- B. Local area network shall be provided with all spare parts, accessories, and appurtenances as herein specified.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 63 43 – Programmable Logic Controllers
- C. Section 40 62 16 – Operator Workstation Computers

**1.03 TOOLS, SUPPLIES AND SPARE PARTS**

- A. The following specific spare parts items shall be provided:
  - 1. A termination tool kit shall be provided containing all required tools and consumables for up to 25 connections of each connection type furnished. Termination kit shall be as manufactured by Black Box, Corning Cable Systems, Optical Cable Corporation, or equal.
  - 2. One spare switch of each type furnished under this Contract.

**PART 2 – PRODUCTS**

**2.01 LOCAL AREA NETWORK (LAN)**

- A. An IEEE 802.3 Ethernet local area network shall be used for communications between plant devices.
- B. Network wiring shall be unshielded, twisted-pair copper cables for connections within buildings. Fiber optic media shall be used for all inter-device communication links extended outside of a building, unless specifically noted. Cables shall be as specified herein.

- C. The Contractor may provide a network configuration different from that shown in the Contract Drawings with written approval of the Engineer, but the Contractor shall coordinate with all affected trades and pay for all additional charges incurred.
- D. The Contractor shall supply all hardware, cables, connectors, and software to implement a network as specified herein and shown on drawings.

## **2.02 CELLULAR MODEM**

- A. Provide a cellular modem with 24V dc power supply, antenna as required for location and connectivity, connecting cables and all other hardware, connectors and software required for cellular communications between the pump station and the Owner's SCADA system through the Owner's Verizon cellular provider. Cellular modem shall be Sierra Wireless AirLink RV50X.
- B. The Owner will coordinate with their cellular provider to obtain a SIM card for the modem and will provide services to integrate the cellular modem into the existing SCADA system.

## **2.03 INDUSTRIAL ETHERNET NETWORK SWITCHES**

- A. Except where specifically allowed on the Control System Architecture Drawing, industrial Ethernet network switches shall be provided for each device connected to the process control system network. The switches shall create switched Ethernet networks that conform to the IEEE 802.3 and 802.3u standards using copper wires or optical fibers in a bus, tree or ring network topology as shown on the Drawings. Ethernet network switches shall be modular, rack mounted, or standard DIN-rail mounted within the PLC cabinet or in an adjacent communication cabinet, as shown on the Drawings.
- B. Ethernet network switches shall support ring, bus, tree, or point-to-point network topologies. On-line signal monitoring shall be provided to detect and locate impending faults. Ethernet network switches shall be replaceable on-line without disrupting the network. The Ethernet network switches shall be integrated into the in-plant Ethernet network to form a redundant ring network with self-healing communication recovery. Switches shall support the non-proprietary Media Redundancy Protocol (MRP) and Rapid Spanning Tree Protocol (RSTP) in addition to the switch manufacturer's standard redundant ring network protocol, all of which shall provide self-healing communication recovery.
- C. Ethernet network switches shall meet the following minimum performance requirements:
  - 1. Functions: Modular managed switch with store and forward switching mode, 10 Mbps Ethernet, or 100 Mbps Fast-Ethernet, or gigabit Ethernet support, multi-address capability, auto-crossing, auto-negotiation, auto-polarity. Port speed and duplex auto-negotiation shall be configurable. Each network switch shall manage up to eight (8) ports possible via integrated media modules specified below.

2. Management: Simple Network Management Protocol (SNMP) (v1/v2/v3) and Common Industrial Protocol (CIP) support; IGMP filtering and snooping.
  3. Power Requirements: Redundant 24 VDC power supply
  4. Operating Temperature: 0 to 60 degrees C
  5. Relative Humidity: 10 - 95%
  6. Network Size: Up to 50 nodes in ring structure
  7. Port Type & Quantity (at each PLC location): minimum of four eight (48) 10/100Base-TX, twisted pair cable, RJ-45 sockets, 0-100 meters LAN segment and two (2) 100/1000Base-FX, multimode fiber optic cables (62.5/125  $\mu$ m), LC, ST or SC sockets, 0-5000 meters LAN segment
  8. Link Budget: 8 dB @ 1300 nm; 10 dB @ 850 nm
  9. Wavelength: 850 or 1300 nm
- D. Acceptable industrial Ethernet network switches shall be as manufactured by Cisco Systems, Hirschmann, Phoenix Contact, Weidmuller, or equal.

#### **2.04 OFFICE-GRADE ETHERNET NETWORK SWITCHES**

- A. Where specifically called out on the Drawings and where located in a suitable office-type environment (e.g., administration areas), office-grade Ethernet switches shall be provided for connectivity to the process control system network.
- B. Office-grade Ethernet switches shall be rack-mounted as shown on the Drawings and shall meet the following specifications:
  1. Functions/Protocol: Same as industrial switches
  2. Power Requirements: Redundant 120 VAC power supply
  3. Operating Temperature: 0° - 40°C
  4. Relative Humidity: 10 - 95%
  5. Port Type & Quantity: Minimum of twelve (12) 10/100Base-TX, twisted pair cable, RJ-45 sockets, 0-100 meters LAN segment; two (2) 100/1000Base-FX, multimode fiber optic uplinks (62.5/125  $\mu$ m), LC, ST or SC sockets, 0-500 meters LAN segment
- C. Office-grade Ethernet switches shall be Catalyst by Cisco Systems, or equal.

#### **2.05 FIBER OPTIC MEDIA CONVERTERS**

- A. Fiber optic media converters shall be provided to transform the specific PLC network communications protocol into an optical signal suitable for transmission over the fiber optic cable specified herein. Fiber optic media converters shall be modular, rack mounted, or mounted within the PLC rack.
- B. Fiber optic media converters shall meet the following minimum performance requirements:
  - 1. Input Power: 110/220 VAC or 24 VDC (as required) for stand-alone panel-mounted modules or +5 VDC for PLC rack-mounted modules
  - 2. Operating Temperature: 0 to 60 degrees C
  - 3. Node-to-Node Distance: 6500 feet
  - 4. Wavelength: 850 or 1300 nanometers
  - 5. Connector Type: SC, LC, or ST
- C. The PLC manufacturer's standard, PLC rack-mounted fiber optic transceiver may also be used, subject to approval by the Engineer.
- D. Port speed and duplex auto-negotiation shall be configurable.
- E. Acceptable fiber optic media converters shall be as manufactured by Black Box, Phoenix Contact or equal.

## **2.06 UNSHIELDED TWISTED PAIR CABLE**

- A. Unshielded twisted pair cable for drops within buildings shall consist of 4 pair of 24 AWG copper conductors in a flame-retardant jacket. Cable shall be plenum rated (UL 910) and meet EIA/TIA-568 Category 6 specifications. Unshielded twisted pair cable shall be Hyper Grade Extended Distance cable as manufactured by Berk-Tek, Belden equivalent, or equal. Connectors shall be modular RJ-45 plug.

## **2.07 FIBER OPTIC CABLE**

- A. Fiber optic cable shall conform to the following specifications:
  - 1. Fiber Type: Graded Index (GI) Multimode
  - 2. Fiber/Cladding Diameter: 62.5/125 microns
  - 3. No. Fibers: 12, Color-coded
  - 4. Cable Construction: Loose Tube w/ Ripcords
  - 5. Filling: Water Swellable Dry Block



6. Armored: No
  7. Central Member: Dielectric (Kevlar)
  8. Rating: Gigabit Ethernet
  9. Bandwidth: 200/500 MHz-km at 850/1300 nm
  10. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm
  11. Application Type: Direct-burial/Conduit/Aerial
  12. Sheath: UV Resistant
  13. Max. Tensile Load: 600 lb (2700 N) installation; 200 lb (890 N) long term
  14. Minimum Bend Radius: 7 in (17.4 cm) under maximum tensile load; 4.6 in (11.6 cm) unloaded (installed)
  15. Operating Temperature: -40 to 70 degrees C
  16. Operating Relative Humidity: 0 to 100%
- B. Fiber optic cable shall be ALTOS All Dielectric Loose Tube Optical Cable as manufactured by Corning Cable Systems, the Extended Performance Fiber Optic Cable Series as manufactured by Phoenix Digital, Inc., Belden equivalent, equivalent system by Optical Cable Corporation, or equal.
- C. Upon entering a cabinet, panel or console, loose tube fiber optic cable shall be broken out using fan-out kits and terminated in a fiber optic patch panel. All individual fibers shall be terminated and all connections shall be tested. Tight buffered cable shall then be routed to the individual destinations as needed (or loose tube cable for runs to other buildings). Cabinet-mounted patch panels shall be Cabinet-Mounted Interconnect Center (C-MIC) as manufactured by Corning Cable Systems, equivalent by Black Box, Inc., Optical Cable Corporation, or equal.
- D. Where cable is required to be routed to numerous, separate destinations within a building, loose tube cable shall be broken out immediately upon entering the building, all individual fibers terminated in a patch panel, and tight buffered, plenum rated cable shall be routed to the individual destinations. Building patch panels shall be Wall-Mountable Interconnect Center (WIC) or Premises Interconnect Center (PIC) as manufactured by Corning Cable Systems, equivalent by Black Box, Inc., Optical Cable Corporation, or equal.
- E. Fiber optic cable for installation within buildings shall comply with all applicable fire and building safety codes for such applications.

- F. Fiber optic cable shall utilize mechanically spliced, field installable, SC, LC, or ST compatible connectors. Connections shall have a typical loss of 0.35 dB or better and shall provide stable optical performance after numerous rematings. Connections shall utilize physical contact terminations utilizing UV or heat cured adhesive. Where applicable, field terminations shall use a simple procedure requiring minimal training.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. The destination of all network data cables (both copper and fiber) leaving an enclosure, patch panel, or building shall be labeled at each end using industry-standard wire markers.
- B. Refer to Section 40 61 13 – Process Control System General Provisions Part 3 of the Specifications for additional requirements.

**END OF SECTION**

**SECTION 40 67 00**  
**CONTROL SYSTEM EQUIPMENT PANELS AND RACKS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place, in satisfactory operation the control enclosures, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.
- B. Control enclosures shall be assembled, wired, and tested in the instrumentation subcontractor's own facilities, unless specified otherwise. All components and all necessary accessories such as power supplies, conditioning equipment, mounting hardware, signal input and output terminal blocks, and plug strips that may be required to complete the system shall be provided.
- C. Either manufacturer's standard or custom enclosures may be furnished subject to the requirements of the Contract Documents and favorable review by the Owner.
- D. Due consideration shall be given to installation requirements for enclosures in new and existing structures. The Contractor shall examine plans and field inspect new and existing structures as required to determine installation requirements and shall coordinate the installation of all enclosures with the Owner and all affected contractors. The Contractor shall be responsible for all costs associated with installation of enclosures, including repair of damage to structures (incidental, accidental or unavoidable).
- E. The terms enclosure, cabinet, and panel shall be considered the same product and are used interchangeably.

**1.02 SUBMITTALS**

- A. Submittals shall be per Section 40 61 15 – Process Control System Submittals.
- B. Thermal calculations.
- C. Proof of circuit breaker selective coordination.

**1.03 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 62 00 – Computer System Hardware and Ancillaries
- C. Section 40 78 00 – Panel Mounted Instruments

- D. Section 40 78 56 – Isolators, Intrinsically-Safe Barriers, and Surge Suppressors
- E. Section 40 70 00 – Instrumentation for Process Systems
- F. Section 40 61 90 – Schedules and Control Descriptions, General
- G. Refer to Division 26 for additional requirements for conductors, circuit breakers, disconnect switches, etc.

#### **1.04 PANEL LOCATION AND TYPE**

- A. For locations inside buildings in areas other than climate controlled (i.e., heated and air conditioned) electrical or control rooms, panel shall be Type 316 stainless steel NEMA 4X construction, or as indicated for hazardous area classification (Class, Division, at a minimum), or submersible, NEMA 6, applications. Epoxy coated cast copper-free aluminum construction shall also be acceptable for NEMA 4, 6 and 7 applications.
- B. For locations in storage/feed areas for chlorine or other applicable corrosive chemicals, panel shall be of non-metallic construction, rated NEMA 4X, and be fully compatible with the associated chemical.
- C. For locations within climate controlled (i.e., heated and air-conditioned) electrical or control rooms, panel shall be a painted steel fully enclosed NEMA 12 units with gasketed doors.
- D. For outdoor locations, panel shall be Type 316L stainless steel NEMA 4X construction unless located in chlorine environments. Chlorine environment shall be nonmetallic NEMA 4X construction.

#### **1.05 TOOLS, SUPPLIES AND SPARE PARTS**

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies and Spare Parts, General.

### **PART 2 – PRODUCTS**

#### **2.01 CABINETS AND PANELS**

- A. Cabinets and panels shall be formed or welded construction, reinforced with Unistrut, Powerstrut, or equal to facilitate mounting of internal components or equipment. Sufficient access plates and doors shall be provided to facilitate maintenance and testing of the cabinet's equipment. Doors shall be removable. Cabinets and panels with any dimension 36 inches or greater shall be provided with removable lifting lugs designed to facilitate safe moving and lifting of the panel during installation. All doors shall be fitted with common-keyed locks.

- B. Cabinets and panels shall be minimum 14 USS gauge. Cabinets and panels with any dimension greater than 36 inches shall be 12 USS gauge.
- C. Cabinets and panels shall have doors on the front and shall be designed for front access. NEMA 12 cabinets shall be fitted with three-point door latches. Doors for NEMA 4X cabinets shall be all stainless steel with three-point latches. Door hardware on NEMA 4X cabinets located in chemical storage/feed areas shall be non-corrosive in that environment.
- D. Panels and cabinets located outside fence-secured areas shall be fitted with padlockable latch kits. Coordinate keying with Owner.
- E. All cabinets and panels shall be provided with drawing pockets for as-built panel drawings. One copy of the appropriate panel as-built drawings shall be furnished and left in the pocket of each panel.
- F. Panels with any dimension greater than 36 inches that contain a programmable controller (PLC) shall be provided with a folding laptop programmer shelf on the inside of the door. When deployed, the laptop shelf shall not be greater than 48 inches above finished floor. Laptop shelf shall be fitted to door with factory applied weld-studs. Weld discoloration and enclosure penetrations will not be accepted.
- G. Unless otherwise noted, panel-mounted control devices (OIUs, hand switches, etc.) requiring operator access shall be mounted between 48 and 60 inches above the floor or work platform.
- H. Cabinets and panels shall be prefabricated cabinets and panels by Hoffman or Saginaw Control and Engineering (SCE). The Contractor may optionally provide cabinets that are custom-fabricated by the instrumentation subcontractor or by a reputable panel fabrication shop acceptable to the Engineer.

## **2.02 FIELD PANELS**

- A. Field panels for outdoor service shall be suitable for wall or pipe mounting. Panels shall have the following features:
  - 1. Hinged and foamed-in-place continuous gasketed door(s). Door material shall match enclosure and shall have piano hinge(s) and three-point latches.
  - 2. Field panels located outside fence-secured areas shall be fitted with staple and hasp. Provide padlock and coordinate keying with Owner.
  - 3. Thermal insulation and thermostatically controlled space heaters where required to prevent condensation or maintain environmental conditions for installed components.

4. External sun shields or shades constructed of the same materials as the associated enclosure, unless otherwise specified. Sun shield or shade shall be fitted to enclosure supports and not to enclosure. Sun shield or shade shall have a slightly sloped top to shed water and shall extend past the front of the enclosure by at least 6 inches and extend down the side and back of enclosure.
- B. All external sample/process piping, including valves and appurtenances, shall be insulated with weather-proof insulation and heat-taped to prevent freezing. Heat taping shall be thermostatically controlled and self-regulating, and shall adjust its heat output to the temperature of the lines. Heat tape shall be powered from an equipment-safety GFCI circuit from within panel, unless otherwise shown or specified.
- C. Field panels shall be adequately sized to house instruments, power supplies, surge protection, and appurtenant equipment required for operation. Sufficient space shall be provided for servicing instruments without removal of equipment from the enclosure.
- D. Field panels shall be as manufactured by Hoffman, Saginaw Control & Engineering (SCE), or equal.

### **2.03 CABINET AIR CONDITIONING UNITS**

- A. Where indicated or required due to ambient conditions and panel component ratings, panel-mounted closed loop air conditioning units and thermostatically controlled space heaters shall be provided.
- B. Air conditioning units shall both cool and dehumidify the cabinet's internal air. Each air conditioner shall be sized to handle current and future (with specified spare capacity filled) heat loadings from all equipment mounted inside the cabinet.
- C. Air conditioners shall be provided with thermostats which operate the centrifugal evaporator blowers continuously to prevent stratification of air within the cabinet. Compressors shall operate as needed to maintain the temperature set at the thermostat. Compressors shall be provided with space heaters to maintain the compressor at a minimum temperature during cold ambient temperatures.
- D. Ambient air shall be completely separated from the air inside the cabinet. All air conditioner components exposed to the atmosphere outside the cabinets shall be coated to prevent corrosion.
- E. Power supply shall be 115VAC, 60 Hz. Units shall be provided with EMI/RFI noise suppressors.
- F. Air conditioner enclosures shall be constructed of stainless steel or cold rolled steel which is phosphatized and finished in baked enamel.
- G. Cabinet air conditioners shall be ProAir CR Series as manufactured by McLean Midwest of Brooklyn Park, MN, or equal.

## **2.04 TERMINAL BLOCKS**

- A. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the cabinet subpanel. Terminals shall be of the screw down pressure plate type as manufactured by Phoenix Contact, Weidmuller, Wieland, Square D, or equal.
- B. Power terminal blocks for both 120 VAC and 24 VDC power shall be single tier with a minimum rating of 600 volts, 30 amps.
- C. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20 amps.

## **2.05 NAMEPLATES**

- A. Items of equipment installed in control panels shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include, as necessary, the equipment identification number, description, calibrated range, and set point(s). Abbreviations of the description shall be subject to the Engineer's approval.
- B. Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background. Nameplates attached to instruments may be black laser etched 1/8-inch high text on stainless steel with sharp edges made smooth. Stamped text shall not be acceptable.
- C. Nameplates shall be attached to metal equipment by NEMA rated stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of a braided stainless steel wire affixed with a permanent crimp.
- D. Submit sample nameplate of each type.

## **PART 3 – EXECUTION**

### **3.01 FABRICATION**

- A. The cabinet itself and all interior and exterior equipment shall be identified with nameplates. The equipment shall be mounted such that service can occur without removal of other equipment. Face mounted equipment shall be flush or semi-flush mounted with flat black escutcheons. All equipment shall be accessible such that adjustments can be made while the equipment is in service and operating. All enclosures shall fit within the allocated space as shown on the Drawings.

- B. Enclosures shall provide mounting for power supplies, control equipment, input/output subsystems, panel-mounted equipment and appurtenances. Ample space shall be provided between equipment to facilitate servicing and cooling.
- C. Enclosures shall be sized to adequately dissipate heat generated by equipment mounted inside the panel. If required, one or more of the following shall be provided to facilitate cooling:
  - 1. For NEMA 12 cabinets only, louvered openings near the bottom and top or thermostatically controlled, low-noise cooling fans to circulate outside air into the enclosure, exhausting through louvers near the top of the cabinet. Air velocities through the enclosure shall be minimized to assure quiet operation.
  - 2. Thermostatically controlled, low noise internal air blowers to circulate air within the enclosure, maintaining a uniform internal temperature. Initial setpoint shall be 75 degrees F.
  - 3. All intake openings in cabinets and panels shall be fitted with dust filters.
- D. Enclosures shall be constructed so that no screws or bolt heads are visible when viewed from the front. Punch cutouts for instruments and other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.
- E. The temperature inside each enclosure containing digital hardware (e.g., PLC, computer, Ethernet switch) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature. This thermostat shall be independent and separate from the thermostat used to control the temperature in the enclosure described above. Enclosure "high interior temperature" alarm shall be displayed on the HMI or OIT.
- F. Intrusion alarm switches shall be provided on all enclosures containing digital hardware and shall generate an alarm to the nearest PLC when any enclosure door is opened. If panel contains a service light, alarm switch shall also be wired to turn light on when door is opened.
- G. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for field incoming conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system will be acceptable.
- H. Wiring within cabinets, panels, and consoles shall be installed neatly and shall comply with accepted standard instrumentation and electrical practices. Power, control and signal wiring shall comply with Division 26 of the Specifications, except that the minimum wire size for discrete signal wiring may be 16 AWG, and for analog wiring may be 18 AWG. For each pair of parallel terminal blocks, the field wiring shall be between the blocks.



- I. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. Where applicable, terminal strips for different voltages of discrete signal wiring shall also be separated. Terminal strips shall be labeled as to voltage and function.
- J. All wiring shall be bundled and run open or enclosed in vented plastic wireway as required. Wireways shall be oversized by a minimum of 10%; overfilled wireways shall not be acceptable. All conductors run open shall be bundled and bound at regular intervals, not exceeding 12 inches, with nylon cable ties. Care shall be taken to separate electronic signal, discrete signal, and power wiring when operating at differing voltages.
- K. Spare field wiring shall be bundled, tied, and labeled as specified above, and shall be neatly coiled in the bottom of the cabinet.
- L. All installed spare I/O hardware shall be wired along with live I/O wiring to the field wiring terminal blocks within the cabinet. Where space for spare I/O modules has been provided with the PLC backplane or DIN-rail mounting system, corresponding space for wiring, surge protection, and terminations shall be furnished within the cabinet.
- M. A copper ground bus shall be installed in each cabinet and shall be connected to the building power ground.
- N. Interior panel wiring shall be tagged at all terminations with machine-printed self-laminating labels. Labeling system shall be Brady TLS 2200 Printer with TLS 2200®/TLS PC Link™ labels, or equivalent system by Seton or Panduit. The wire numbering system and identification tags shall be as specified in Section 26 05 19 – Low-Voltage Conductors and Cables. Field wiring terminating in panels shall be labeled in accordance with the requirements of Section 26 05 19 – Low-Voltage Conductors and Cables. Where applicable, the wire number shall be the ID number listed in the input/output schedules.
- O. Wires shall be color coded as follows:
  - 1. Equipment Ground – GREEN
  - 2. 120 VAC Power – BLACK
  - 3. 120 VAC Power Neutral – WHITE
  - 4. 120 VAC Control (Internally Powered) – RED
  - 5. 120 VAC Control (Externally Powered) – YELLOW
  - 6. 24 VAC Control – ORANGE

7. DC Power (+) – RED
  8. DC Power (-) – BLACK
  9. DC Control – BLUE
  10. Analog Signal – BLACK/WHITE or BLACK/RED
- P. Enclosures shall be provided with a main circuit breaker and a circuit breaker on each individual branch circuit distributed from the panel. Main breaker and branch breaker sizes shall be coordinated such that an overload in a circuit will trip only its immediate breaker and not the upstream breaker.
- Q. Enclosures with any dimension larger than 36 inches shall be provided with 120-volt duplex receptacles for service equipment and LED service lights. Power to these devices shall be independent from the PLC power supply and its associated uninterruptible power system.
- R. Where applicable, enclosures shall be furnished with red laminated plastic warning signs in each section. The sign shall be inscribed "WARNING - This Device Is Connected to Multiple Sources of Power." Letters in the word "WARNING" shall be 0.75 inch high, white.
- S. The interconnection between equipment and panel shall be by means of flexible cables provided to permit withdrawal of the equipment from the cabinet without disconnecting the plugs.

### **3.02 PAINTING/FINISHING**

- A. All steel enclosures shall be free from dirt, grease, and burrs and shall be treated with a phosphatizing metal conditioner before painting. All surfaces shall be filled, sanded, and finish coated by spraying a 1-2 mil epoxy prime coat and smooth, level, high grade textured finish between flat and semi-gloss shine. The colors shall be selected by the Owner from a minimum of six color samples provided. Refer to Division 9 for additional requirements.
- B. Materials and techniques shall be of types specifically designed to produce a finish of superior quality with respect to adherence, as well as impact and corrosion resistance.
- C. Panels fabricated from stainless steel shall not be painted.
- D. Panels fabricated from non-metallic materials (e.g., FRP) shall be gel-coated and shall not be otherwise painted.

### **3.03 INSTALLATION**

- A. Refer to Section 40 61 13 – Process Control System General Provisions for additional requirements.

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**SECTION 40 67 63**  
**UNINTERRUPTIBLE POWER SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all uninterruptible power systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.
- B. One UPS shall be provided for each operator workstation and its peripherals (i.e. printer, network equipment, radio, etc.) provided under this Contract.
- C. One UPS shall be provided for each programmable logic controller (PLC) panel or remote telemetry unit (RTU) and its appurtenant equipment provided under this Contract. However, courtesy receptacles in PLC and RTU cabinets shall not be powered by the UPS.
- D. UPS units shall be mounted in or near enclosures containing digital hardware, unless otherwise specified or shown on the Drawings, as follows:
  - 1. UPS units for operator's consoles shall be mounted within the consoles.
  - 2. UPS units for control panels containing PLCs shall be mounted either within the cabinet or in an adjacent cabinet of suitable environmental rating.
  - 3. UPS units for RTUs shall be mounted within the RTU cabinet.
  - 4. Where the UPS is mounted within a dedicated enclosure, that enclosure shall be properly sized for heat dissipation and all other applicable requirements as specified in Section 40 67 00 – Control System Equipment Panels and Racks and its subordinate Sections.
  - 5. Where the UPS is mounted within the PLC or RTU cabinet, it shall not interfere with access to other equipment or wiring within the panel (i.e., it shall not be necessary to move or remove the UPS to remove or service other panel-mounted equipment). For floor-mounted PLC cabinets with bottom wiring access (including those cabinets with legs), the UPS shall be placed on a dedicated shelf within the cabinet.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 62 00 – Computer System Hardware and Ancillaries

- C. Section 40 63 43 – Programmable Logic Controllers

### **1.03 SUBMITTALS**

- A. The Contractor shall submit UPS sizing calculations for all UPS units furnished under this Contract in accordance with Section 40 61 15 – Process Control System Submittals.

## **PART 2 – EQUIPMENT**

### **2.01 UNINTERRUPTIBLE POWER SYSTEMS**

- A. Each UPS shall consist of a freestanding UPS module and battery modules as required to meet backup run time requirements.
- B. UPS units shall be true on-line type. Each UPS shall be sized to match the maximum power requirements of the associated digital equipment, control panel power supplies and accessories. Under normal operation, the AC power shall be converted to DC. The DC power from the battery charger shall supply an inverter and maintain the battery module at full charge. The AC output from the inverter shall be fed to the associated digital equipment power supply unit and/or other equipment power supplies as appropriate. Upon loss of the AC supply, the inverter shall continue to supply normal power to the device, drawing DC from the batteries.
- C. An automatic bypass switch shall be provided on UPS units of greater than 2 kVA capacity. The transfer switch shall be of the solid state, make-before-break type and shall automatically transfer load from the inverter to the AC line in the event of an inverter malfunction. The total transfer time shall be 5 milliseconds or less. The transfer switch shall be provided with a manual override.
- D. A manually operated maintenance bypass switch shall be provided for each UPS installation to allow hardware to be powered while the UPS is removed for maintenance. The bypass switch shall be the make-before-break type to ensure continuous power to the associated PLC.
- E. Loss of AC power shall be monitored on the line side of the UPS and reported via normally closed (fail safe) unpowered contacts to the associated PLC/RTU.
- F. Each UPS shall meet the following requirements:
  - 1. Input voltage shall be 117 VAC, single phase, 60 Hz.
  - 2. Voltage regulation shall be +/-5 percent for line and load changes.
  - 3. The output frequency shall be phase-locked to the input AC line on AC operation and shall be 60 hertz +/-0.5 percent when on battery operation.

4. The batteries shall be of the sealed, lead acid or lead calcium gelled electrolyte type, or VRLA absorbed glass mat (AGM) type. The battery modules shall have a minimum full load backup time of 30 minutes for PLC-based control panels, and 45 minutes for remote telemetry units.
  5. A status monitoring and control panel shall be provided and shall include the following:
    - a. Status indicating lights for both normal and abnormal conditions.
    - b. Individual alarm contacts that shall close upon loss of the AC line, low battery level or operation of the static transfer switch. Contacts shall be wired to the closest discrete input subsystem. Alternatively, an RS-232 or USB port shall provide UPS status to an operator workstation. All required interface software and hardware shall be provided.
    - c. Circuit breaker for the AC input.
  6. Sound absorbing enclosure.
  7. EMI/RF noise filtering.
  8. Surge protection shall be provided on the AC input circuit, which shall have a UL TVSS clamping voltage rating of 400 V with a <5 ns response time.
- G. UPS systems shall be the 9PX series by Eaton, Smart-UPS On-line series by APC/Schneider-Electric, or equal.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. Refer to Section 40 61 13 – Process Control System General Provisions, Part 3.

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**SECTION 40 68 00.13**  
**PROCESS CONTROL SOFTWARE (MODIFY EXISTING)**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install, and place in satisfactory operation all control and information system software with all required programming and software appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 93 – Control System Input/Output List
- C. Section 40 61 96 – Process Control Descriptions

**PART 2 – PRODUCTS - (NOT USED)**

**PART 3 – EXECUTION**

**3.01 OVERALL SYSTEM CONFIGURATION**

- A. The Owner's existing Human-Machine Interface (HMI) software, including but not limited to all relevant displays, alarm summary pages, data collection, and historical trending/reporting, shall be modified to include all work performed under this Contract.
- B. The Owner's existing control system shall be modified to include the inputs and outputs specified in the Input/Output Schedule and in other Sections of this Division.

**3.02 SOFTWARE MODIFICATIONS**

- A. All HMI software configuration performed under this Contract shall be coordinated with the Owner and shall match in all possible respects the "look and feel," in the opinion of the Engineer, of the existing SCADA System. Specified features and functions of this Contract that do not already exist, even if only for "look and feel," shall be provided. Details on how to best implement these features and functions shall be discussed with Owner and Engineer.
- B. Major HMI software scope of work shall include, but shall not be limited to, the following:

1. Create new graphic displays showing the new facilities and functions described herein complete with all associated equipment and instrumentation.
  2. Modify the existing plant overview display(s) for the SCADA system to include the new facilities and equipment, and create links to the new screens.
  3. Modify existing alarm summary pages to incorporate new monitoring data into the alarm displays.
  4. Modify existing reports to include the additional monitoring points specified under this Contract.
  5. Create new real-time and historical trends, and coordinate with the Owner appropriate grouping of the trend charts.
  6. Update the system status display to include new hardware provided under this Contract.
- C. Ladder logic resident in existing PLCs shall be modified to perform the functions described as specified herein and in Section 40 61 96 – Process Control Descriptions. Specifically, the existing PLCs shall be programmed to accept the I/O specified in Section 40 61 93 – Control System Input/Output List and to make this data readily available on the plant network and shall be programmed to execute the logic necessary to implement all control functions associated with the scope of work specified under this Contract.
- D. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level. The HMI software shall not be used for this purpose.

**END OF SECTION**

**SECTION 40 70 00**  
**INSTRUMENTATION FOR PROCESS SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The instrumentation subcontractor shall furnish, install, test and place in operation instruments as scheduled together with all signal converters, transmitters, isolators, amplifiers, etc. to interface with the process control system as shown on the Drawings and as specified. The Contractor may elect to install sensors on process lines provided that the instrumentation subcontractor provides full on-site supervision during installation. Mounting of associated indicators, sensors, sampling pumps, power supplies, brackets and appurtenances shall be provided as indicated.
- B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The Instrumentation Subcontractor shall supervise installation of equipment provided where installation is by other Subcontractors or Contractors.
- C. Tapping and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instruments are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 67 00 – Control System Equipment Panels and Racks
- C. Section 40 79 00 – Miscellaneous Instruments, Valves, and Fittings
- D. Section 40 61 22 – Tools, Supplies, and Spare Parts, General.
- E. Instruments furnished with mechanical equipment shall be furnished, installed, tested and calibrated as specified elsewhere in the Contract Documents.

**1.03 TOOLS, SUPPLIES AND SPARE PARTS**

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 -- Tools, Supplies, and Spare Parts, General.

- B. Additional items as recommended by the analytical instrument manufacturers or as described for the specified analytical instrument sections shall be provided.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required.
- B. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Drawings, to comply with the National Electrical Code.
- C. All field instrumentation for outdoor service shall be provided with enclosures that are suitable for outdoor service, as follows:
  - 1. Where the manufacturer's enclosures are suitable for outdoor service, they shall be provided with instrument sunshades. Sunshades shall be Style E as manufactured by O'Brien Corporation, or equal. Where possible, these instruments shall be mounted in a north facing direction.
  - 2. Where the manufacturer's standard enclosures are not suitable for outdoor service, instruments shall be mounted in Field Panels in accordance with Section 40 67 00 – Control System Equipment Panels and Racks, or may be furnished with Vipak instrument field enclosures as manufactured by O'Brien Corporation, equivalent by Intertec, or equal. It shall not be necessary to provide the manufacturer's NEMA 4 or 4X enclosures for instruments that will be subsequently mounted in separate field panels.
- D. All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.
- E. Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in Subsection 3.01 B herein. All indicator readouts shall be linear in process units. Readouts of 0 100% shall not be acceptable (except for speed and valve position). Isolated outputs shall be provided for all transmitters.
- F. Unless otherwise specified, field instrument and power supply enclosures shall be 316 stainless steel, fiberglass (or similar, per Engineer's judgement) or PVC coated copper-free cast aluminum NEMA 4X construction.

- G. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.
- H. Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture and fungus. Solid state components shall be conservatively rated for long term performance and dependability over ambient atmosphere fluctuations. Ambient conditions shall be -20 to 50 degrees C and 20 to 100 percent relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.
- I. All devices furnished hereunder shall be heavy duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.
- J. All non-loop-powered instruments and equipment shall be designed to operate on a 60 Hz AC power source at a nominal 117 V, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.
- K. All analog transmitter and controller outputs shall be isolated, 4 to 20 milliamps into a load of 0 to 750 ohms, unless specifically noted otherwise. All switches shall have double pole, double throw contacts rated at a minimum of 600 VA, unless specified otherwise.
- L. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.

## **2.02 ANALYTICAL INSTRUMENTATION**

- A. Liquid samples shall not pass through housings containing analyzer electronics. Process fluid temperature will be within a range of 40 to 90 degrees F.
- B. Where ambient temperatures will affect accuracy by more than 1 percent of span, a suitable isothermal enclosure with thermostatically controlled space heater shall be provided.
- C. Sample assemblies shall be suitable for submersion or flow-through service as noted and shall be chemically inert to constituents of raw wastewater solids or other chemical environment, as scheduled. Where the sample is drawn prior to filtration, the sample assemblies shall be capable of handling solids and grease.

- D. Each analyzer requiring reagents and/or other replaceable parts shall be furnished with sufficient chemicals and replaceable parts for startup and acceptance tests and the specified warranty period.
- E. Contractor's submittals on these analyzers shall include information on monthly reagent consumption and a list of replaceable parts required for periodic maintenance and the recommended operating periods between replacements. Installation of analyzers and sample preparation shall be in accordance with the analyzer manufacturer's instructions.
- F. Analysis instrumentation performance, accuracy and reproducibility shall be as prescribed in APHA/AWWA/WEF "Standard Methods for the Examination of Water and Wastewater", latest edition. For those measurements specified herein, for which performance characteristics are not listed in the above, the supplier shall state instrument performance characteristics. The "referee" method shall be as prescribed in EPA Methods for Chemical Analysis of Water and Wastes (1971).

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

#### **A. General**

- 1. Equipment shall be located so that it is accessible for operation and maintenance. The instrumentation subcontractor shall examine the Drawings and shop drawings for various items of equipment in order to determine the best arrangement for the work as a whole and shall supervise the installation of process instrumentation supplied under this Division.
- 2. Electrical work shall be performed in compliance with all applicable local codes and practices. Where the Contract Documents do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

#### **B. Equipment Mounting and Support**

- 1. Field equipment shall be wall mounted or mounted on two-inch diameter pipe stands welded to a 10 inch square by 1/2 inch thick base plate unless shown adjacent to a wall or otherwise noted. Materials of construction shall be aluminum or 316 stainless steel. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2 inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.
- 2. Embedded pipe supports and sleeves shall be Schedule 40, Type 316 stainless steel pipe, ASA B 36.19, with stainless steel blind flange for equipment mounting, unless otherwise indicated.

3. Materials for miscellaneous mounting brackets and supports shall be Type 316 stainless steel construction.
4. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.
5. Transmitters shall be oriented such that output indicators are readily visible.

C. Control and Signal Wiring

1. Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid tight flexible conduit. Conduit seals shall be provided where conduits enter all field instrument enclosures and all cabinetry housing electrical or electronic equipment.

### **3.02 ADJUSTMENT AND CLEANING**

- A. The instrumentation subcontractor shall comply with the requirements of Division 1 of these Specifications and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative(s), reserves the right to witness any test, inspection, calibration or start up activity. Acceptance by the Engineer of any plan, report or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.
- B. The instrumentation subcontractor shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the Owner. The Contractor shall bear all costs and provide all personnel, equipment and materials necessary to implement all installation tests and inspection activities for equipment specified herein.
- C. At least 60 days before the anticipated initiation of installation testing, the Contractor shall submit to the Engineer a detailed description, in duplicate, of the installation tests to be conducted to demonstrate the correct operation of the instrumentation supplied hereunder.
- D. Field instrument calibration shall conform to the following requirements:
  1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate or verify factory calibration of each instrument supplied under this Contract and existing instruments shown to its specified accuracy in accordance with the manufacturer's

specification and instructions for calibration. Calibration and verification shall take place under actual process conditions. Forcing outputs shall not be acceptable.

2. Each instrument shall be calibrated/verified at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy's as set forth by the National Institute for Standards and Technology (NIST).
3. The instrumentation subcontractor shall provide a written calibration/verification sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, brief description of how the calibration process was performed, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made. For electronic or powered instruments, the calibration/verification sheet shall also list all configurable parameters that have been modified from their default factory setting.
4. If doubt exists as to the correct method for calibrating or checking the calibration/verification of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.
5. Upon completion of calibration, devices calibrated hereunder shall not be subjected to adjustments, sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to over-voltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and re-calibrated/verified at no cost to the Owner. Equipment that has been adjusted, modified, or moved or there is evidence of such activity shall be re-calibrated/verified at no cost to the Owner.
6. After completion of instrumentation installation, the instrumentation subcontractor shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

#### **END OF SECTION**



**SECTION 40 71 13.13**  
**INLINE MAGNETIC FLOW METERS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the magnetic flow meters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

**1.03 TOOLS, SUPPLIES AND SPARE PARTS**

- A. Furnish one spare signal converter.

**PART 2 – PRODUCTS**

**2.01 MAGNETIC FLOW METER SYSTEMS**

- A. Magnetic flow meter systems shall include a magnetic flow tube and a microprocessor-based "smart" transmitter that is capable of converting and transmitting a signal from the flow tube. Magnetic flow meters shall utilize the characterized field principle of electromagnetic induction and shall produce DC signals directly proportional to the liquid flow rate.
- B. Each meter shall be furnished with a 316 stainless steel or carbon steel metering tube and carbon steel flanges with a polyurethane, ceramic, neoprene, hard rubber, or Teflon liner as required by the application and/or as specified herein. Liner shall have a minimum thickness of 0.125 inches. The inside diameter of the liner shall be within 0.125 inches of the inside diameter of the adjoining pipe. Liner protectors shall be provided on all flow tubes.
- C. The flow tube shall be provided with flush mounted electrodes.
- D. Grounding rings shall be provided for both ends of all meters.
- E. All materials of construction for metallic wetted parts (electrodes, grounding rings, etc.) shall be minimum 316 stainless steel, but shall be compatible with the process fluid for each meter in accordance with the recommendations of the manufacturer.

- F. Flow tube shall be rated for pressures up to 1.1 times the flange rating of adjacent piping. System shall be rated for ambient temperatures of 30 to +65°C. Meter and transmitter housings shall meet NEMA 4X/IP66 requirements as a minimum. When meter and transmitter are located in classified explosion hazard areas, the meter and transmitter housings shall be selected with rating to meet the requirements for use in those areas. Where the flow tube is subject to submergence through installation in a meter vault or similar location, the flow tube assembly shall be rated NEMA 6P/IP68 and electronics shall be factory sealed against moisture intrusion. The use of field kits for modifying NEMA 4/4X/IP66 flow tubes to submergence duty shall not be acceptable. The associated transmitter shall be located in an area not subject to submergence.
- G. The transmitter shall provide pulsed DC coil drive current to the flow tube and shall convert the returning signal to a linear, isolated 420 mA DC signal. The transmitter shall utilize "smart" electronics and shall contain automatic, continuous zero correction, signal processing routines for noise rejection, and an integral LCD readout capable of displaying flow rate and totalized flow. The transmitter shall continuously run self-diagnostic routines and report errors via English language messages.
- H. The transmitter's preamplifier input impedance shall be a minimum of 109-1011 ohms which shall make the system suited for the amplification of low-level input signals and capable of operation with a material build up on the electrodes.
- I. The transmitter shall provide an automatic low flow cutoff below a user configurable low flow condition (0-10%). The transmitter's outputs shall also be capable of being forced to zero by an external contact operation.
- J. Each flow tube shall be factory calibrated and assigned a calibration constant or factor to be entered into the associated transmitter as part of the meter configuration parameters. Manual calibration of the flow meter shall not be required. Meter configuration parameters shall be stored in nonvolatile memory in the transmitter. An output hold feature shall be provided to maintain a constant output during configuration changes.
- K. The transmitter shall be capable of communicating digitally with a remote configuration device via a frequency shift keyed, high frequency signal superimposed on the 420 mA output signal. The remote configuration device shall be capable of being placed anywhere in the 4-20 mA output loop. The remote configuration device shall be as specified under Section 40 70 00 – Instrumentation for Process Systems. A password-based security lockout feature shall be provided to prevent unauthorized modification of configuration parameters.
- L. Accuracy shall be 0.30% of rate over the flow velocity range of 1.0 to 10.0 m/s (3.0 to 33 ft/sec) and 0.5% between 0.1 m/s and 1.0 m/s (1-3 ft/s). Repeatability shall be + 0.1% of rate; minimum turndown shall be 100:1. Minimum required liquid conductivity shall not be greater than 5 uS/cm. Maximum response time shall be adjustable between 1 and 100 seconds as a minimum. Transmitter ambient temperature operating limits shall be 10 to +50°C. Power supply shall be 115 VAC, 60 Hz.

- M. Flow tubes shall be 150-lb flange mounted unless otherwise noted. The cables for interconnecting the meter and transmitter shall be furnished by the manufacturer. Transmitter shall be mounted integrally on flow tube, wall, or 2-inch pipe mounted as shown in the Drawings and/or as specified.
- N. Magnetic flow meter systems shall be Model 8750W with optional high accuracy as manufactured by Rosemount, or equivalent by or Yokogawa.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. Ground magnetic flow meter flow tubes and grounding rings in strict accordance with the manufacturer's recommendations.
- B. Refer to Section 40 70 00 – Instrumentation for Process Systems.

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**SECTION 40 72 13**  
**ULTRASONIC LEVEL METERS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the ultrasonic liquid level measurement systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 60 13 – Process Control System General Provisions
- B. Section 40 61 22 – Tools, Supplies, and Spare Parts, General
- C. Section 40 70 00 – Instrumentation for Process System

**1.03 TOOLS, SUPPLIES AND SPARE PARTS**

- A. Tools, supplies, and spare parts shall be per Section 40 61 22 – Tools, Supplies, and Spare Parts, General.

**PART 2 – PRODUCTS**

**2.01 ULTRASONIC LEVEL CONTROLLERS**

- A. The ultrasonic differential level monitoring system shall include two ultrasonic level sensors and an "intelligent" transmitter (controller) with display and integral keypad. The ultrasonic differential level monitoring system shall be required to monitor the levels of process liquids or solids and transmit an analog signal linear with differential level. Location of the sensors and transmitter shall be as shown on the Drawings and/or as specified.
- B. For outdoor installation, the use of approved watertight conduit hub/glands shall be required. Tank mounting applications, unless otherwise indicated, shall include mounting flange adapter supplied by the manufacturer, which is compatible with the process media and the tank flange connection. Channel or wall mounting applications shall include mounting bracket supplied by the manufacturer and constructed of 316 stainless steel material. Sensor mounting thread shall be 1" NPT.
- C. The level sensors shall be unaffected by moisture droplets on the transducer face and operate on the ultrasonic echo ranging principle. The sensors shall also be fully

submersible and resistant to corrosive materials. Sensor accuracy shall be a minimum of 0.25 percent of level measurement range and include integral temperature compensation with an accuracy of 0.09% of range. Resolution shall be at least 0.1 percent of full range or 0.08 inches, whichever is greater.

- D. The transmitter shall be programmable through the integral HMI display. Display shall be LCD with backlighting, shall have the capability to display a minimum of 4 characters at one time, and shall be shielded from direct sunlight. The units shall have as a minimum, the required number of programmable set points to perform the functions specified. Each set point shall operate a set of contacts rated at 5 amps, 250 VAC, non-inductive.
- E. The transmitter shall compensate for changes in temperature and air density. The controller shall be capable of performing the following functions: level monitor, both linear and nonlinear level to flow relationships, volumetric, open channel flow monitoring, differential control, and control of up to 6 pumps, alarms, monitor pump runtime and pump sequencing. Output level signal shall be linear, isolated 4 20 mA DC. Power requirement for the transmitter shall be 120 VAC, 60 Hz. The unit shall have a NEMA 4X stainless steel or nonmetallic enclosure.
- F. Transducers shall be rated NEMA 6P and also rated for the appropriate hazardous area rating according to the Contract Documents, if located in such an area. Contractor shall coordinate length of transducer cable. Splices shall not be permitted, unless otherwise indicated.
- G. Ultrasonic level measurement system shall be the HydroRanger 200 HMI transmitter and Echomax Series Transducers as manufactured by Siemens, or equal.

## **2.02 REQUIREMENTS**

- A. Where two or more ultrasonic level instruments are mounted in close proximity to each other, the transmitters shall coordinate operation to prevent interference from adjacent units. Coordination shall be accomplished via an interconnecting communication cable.
- B. Where level transducers may become submerged, provide a manufacturer-supplied submergence hood.
- C. Where ultrasonic level systems are used on solids measurement applications, provide a swiveling aiming device to allow easy adjustment of beam direction.
- D. For open channel flow applications where the transducer is subject to direct sunlight, use an externally mounted temperature compensator mounted out of direct sunlight.
- E. Refer to Section 40 70 00 – Instrumentation for Process System for additional requirements.

**END OF SECTION**

**SECTION 40 72 76.13**  
**MULTIPLE POINT LEVEL SWITCHES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the multiple switch level probes, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 67 00 – Control System Equipment Panels and Racks
- C. Section 40 70 00 – Instrumentation for Process Systems

**PART 2 – PRODUCTS**

**2.01 MULTIPLE SWITCH LEVEL PROBES**

- A. Multiple switch level probes shall be constructed as a slim rod from CPVC or PVC material with metal contacts at regular intervals along the probe. The metal contacts shall be high-grade stainless steel. The probe shall be sealed and potted to ensure that the unit is waterproof. The probe shall be of impact resistant construction and shall be able to withstand a drop test onto concrete from 6 feet with one end being let go before the other end.
- B. Operating temperature range shall be 0 to 65 degrees C (32 to 149 degrees F).
- C. Up to ten metal contacts shall be spaced along the length of the probe assembly, and each shall be individually connected to one core of cable. The cores shall be color coded for wiring into the controller (or equivalent identifier). The metal contacts shall be placed to minimize the opportunity for rags to short between contacts. For example, a small contact with minimal protrusion from the surface of the rod, offset by 120 degrees from the contact above.
- D. Level monitoring range and elevations shall be as shown on the Drawings.
- E. The flexible cable assembly shall be capable of supporting the weight of the probe and cable, without the need for additional support. The cable retained shall ensure that the probe to cable connection can support at least 100 pounds of weight. The cable shall be shielded.

- F. Level probe shall be UL or FM approved for installation in Class 1, Division 2 hazardous areas without any barrier. Class I Division 1 shall be achieved with a suitable approved barrier. See Electrical Drawings for Area Classification.
- G. Multiple switch level probes shall be the MultiTrode Probe as manufactured by MultiTrode, Inc.; FOGRod as manufactured by Wastewater Level, LLC; or equal.

## **2.02 PROBE INTERFACE**

- A. If required, the probe shall be provided with an interface to connect to the probe's multiple sensing elements and provide relay outputs suitable for connection to a PLC or a dedicated pump controller system.
- B. Interface shall be capable of accepting up to ten (10) probe inputs and shall provide ten (10) relay outputs. Interface outputs shall be programmable for the following selectable time delays: 0, 5, 10, or 15 seconds. Relay contact outputs shall be rated 5 A resistive and 2 A inductive at 250 VAC operating voltage.
- C. Interface shall have a 10-LED bar graph display and one power on LED light. The unit shall be powered from 120 VAC directly or via a suitable 120 VAC to 24 VDC power supply. Operating temperature range shall be 14 degrees F to 140 degrees F.
- D. Interface shall be of the same manufacturer as the probe and shall be the MTR relay as manufactured by Xylem, Inc.; the LIT-100 as manufactured by Wastewater Level, LLC; or equal.

## **2.03 INTRINSICALLY SAFE BARRIER**

- A. An intrinsically safe barrier (ISB) shall be provided between the level probe and the controller when the level probe is installed in classified hazardous areas. The barrier shall be compatible with the controller equipment and sensing device specified above.
- B. ISB shall be Model MTISB as manufactured by Multitrode, Inc.; equivalent by Wastewater Level, LLC; or equal.

## **PART 3 - EXECUTION**

### **2.04 REQUIREMENTS**

- A. The probe shall be installed as shown on the Drawings in accordance with the manufacturer's recommendations and requirements.
- B. The probe shall be suspended on its own cable and connected to a 6 mm, Type 316 stainless steel hook or mounting bracket which shall hang from a Type 316 stainless steel angle containing a polyurethane squeegee pad, so that the probe can be removed without entering the wet well. The squeegee shall have an appropriately sized hole and slot, enabling the probe to be pulled through and cleaned. Probe mounting hardware



shall be MTAK 1 Mounting Bracket, as manufactured by Multitrode, Inc.; equivalent by Wastewater Level; or equal.

- C. Probe cable shall be run in a separate conduit away from power cables in accordance with the requirements Section 40 61 24 – Quality Assurance and the manufacturer's recommendations.
- D. Refer to Section 40 70 00 – Instrumentation for Process Systems.

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**SECTION 40 72 76.26**  
**LEVEL SWITCHES (FLOATS)**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the float level switches, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

**PART 2 – PRODUCTS**

**2.01 LEVEL SWITCHES (FLOATS)**

- A. Level switches of the direct acting float-operated design shall be comprised of a hermetically sealed, approximately 5-inch diameter plastic casing float, containing microswitches and flexibly supported by means of a heavy neoprene or PVC jacket, with three-conductor cable a minimum of 20 feet in length. Unless otherwise specified, media specific gravity is 0.95 to 1.05. Provide floats with two SPDT microswitches, 5A, 115V AC capacity. Float hangers and supports shall be provided as shown on the installation detail drawings.
- B. Float switches shall be Model ENM as manufactured by Flygt, or equal.

**PART 3 – EXECUTION**

**3.01 REQUIREMENTS**

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

**END OF SECTION**

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**SECTION 40 73 13**  
**PRESSURE AND DIFFERENTIAL PRESSURE GAUGES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure gauges, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems
- C. Section 40 79 00 – Instrumentation Accessories

**PART 2 – PRODUCTS**

**2.01 PRESSURE GAUGES**

- A. All gauges shall be designed in accordance with the ASME B40.1 entitled, "Gauges, Pressure, Indicating Dial Type - Elastic Element".
- B. All gauges shall be direct reading type. Snubbers shall be provided on all gauges. Gauge full-scale pressure range shall be selected such that the maximum operating pressure shall not exceed approximately 75% of the full-scale range.
- C. Features
  - 1. Mounting: ½" NPT, lower stem mount type
  - 2. Accuracy: 0.5% full scale
  - 3. Case: Solid front, black phenolic material
  - 4. Dial: White background and black letters
  - 5. Glass: Shatterproof
  - 6. Blow-out protection: Back
  - 7. Pressure element: stainless steel bourdon tube

- 8. Movement: Stainless steel, Teflon coated pinion gear and segment
- 9. Gaskets: Buna-N
- D. Liquid-filled or equivalent mechanically-damped gauges shall be used if the gauges are installed with pumps, or where gauges are subjected to vibrations or pulsation. Filling fluid shall be silicone unless oxidizing agents such as sodium hypochlorite are present, where halocarbon shall be used.
- E. Gauge size shall be 4-1/2".
- F. Diaphragm seals and isolating ring seals shall be furnished in accordance with the requirements specified under Section 40 79 00 – Miscellaneous Instruments, Valves, and Fittings.
- G. The complete gauge assembly and appurtenances shall be fully assembled and tested prior to field mounting. A 1/2" isolation stainless steel ball valve shall be provided for each gauge assembly.
- H. Pressure and vacuum gauges shall be Ashcroft Duragauge Model 1279, Ametek-U.S. Gauge Division, H.O. Trerice Co., WIKA Instrument Corporation, or equal.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

**END OF SECTION**

**SECTION 40 73 20**  
**PRESSURE TRANSMITTERS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure indicating transmitters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

**PART 2 – PRODUCTS**

**2.01 GAUGE PRESSURE INDICATING TRANSMITTERS**

- A. Gauge pressure transmitters shall be of the capacitance type with a process-isolated diaphragm with silicone oil fill, microprocessor-based "smart" electronics, and a field adjustable rangeability of 100:1 input range. Span and zero shall be continuously adjustable externally over the entire range. Span and zero adjustments shall be capable of being disabled internally. Transmitters shall be NEMA 4X weatherproof and corrosion resistant construction with low-copper aluminum body and 316 stainless steel process wetted parts. Accuracy, including nonlinearity, hysteresis and repeatability errors shall be plus or minus 0.025 percent of calibrated span, zero based. The maximum zero elevation and maximum zero suppression shall be adjustable to anywhere within sensor limits. Output shall be linear isolated 4-20 milliamperes 24 VDC. Power supply shall be 24 VDC, two-wire design. Each transmitter shall be furnished with a 4-digit LCD indicator capable of displaying engineering units and/or milliamps and mounting hardware as required. Overload capacity shall be rated at a minimum of 25 MPa. Environmental limits shall be -40 to 85 degrees Celsius at 0-100% relative humidity. Each transmitter shall have a stainless steel tag with calibration data attached to body.
- B. The piezoresistive silicon pressure sensor shall be mechanically, electrically, and thermally isolated from the process and the environment, shall include an integral temperature compensation sensor, and shall provide a digital signal to the transmitter's electronics for further processing. Factory set correction coefficients shall be stored in the sensor's non-volatile memory for correction and linearization of the sensor output in the electronics section. The electronics section shall correct the digital signal from the sensor and convert it into a 4-20 mA analog signal for transmission to receiving devices.

The electronics section shall contain configuration parameters and diagnostic data in non-volatile EEPROM memory and shall be capable of communicating, via a digital signal superimposed on the 4-20 mA output signal, with a remote interface device. Output signal damping shall be provided, with an adjustable time constant of 0-36 seconds. Total long term stability (frequency of calibration) shall be not less than 0.20% URL for 15 years.

- C. Where scheduled, gauge pressure indicating transmitters shall be calibrated in feet of liquid for liquid level service.
- D. Gauge pressure indicating transmitters shall be Model 3051S1TG as manufactured by Emerson Process Management (Rosemount), or equal.

### **PART 3 – EXECUTION**

#### **3.01 REQUIREMENTS**

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

**END OF SECTION**



**SECTION 40 76 21**  
**SINGLE POINT GAS MONITORING SYSTEMS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the single point gas monitoring systems with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Analytical Instrumentation for Process Systems

**1.03 TOOLS, SUPPLIES AND SPARE PARTS**

- A. One spare sensor of each type used shall be provided.
- B. Calibration equipment and controller as recommended by the manufacturer and a one-year supply of calibration gas for each gas measured shall be provided to field-calibrate the gas monitoring systems.

**PART 2 – PRODUCTS**

**2.01 GENERAL**

- A. Gas monitoring systems shall include a sensor to monitor specified gas and a microprocessor-based transmitter that is capable of accepting, converting and transmitting signals from the sensor. The complete gas monitoring system including sensor, transmitter, and accessory equipment shall be supplied by a single manufacturer. One system shall be provided per gas per location.

**2.02 SENSORS**

- A. All sensors shall sample and monitor the atmosphere without the aid of pumps or other mechanical devices. Sensors and associated enclosures shall be classified as Class 1, Division 1, Group C and D as specified by the National Electric Code. Sensors shall be mounted with non-corrosive hardware as shown in the Drawings and/or as recommended by the manufacturer.

- 1. Combustible Gas Sensor – The combustible gas sensor shall be the infrared (IR) type. It shall be immune to poisoning by hydrogen sulfide and silicone. The IR

combustible sensor shall be capable of calibration without gas and shall be capable of performing a full calibration by zero adjustment only. The IR sensor shall allow detection of an above 100% LEL condition (over-range). The IR sensor shall not contain a flashback arrestor / frit.

2. Electrochemical (Toxic and Oxygen) Sensor – Sensors to detect toxic gases and oxygen shall be of the electrochemical type and shall not require the periodic addition of reagents.
- B. Sensors shall be contained in sensor modules mounted externally to the main enclosure. All sensor modules shall have the capability of replacement while the unit is under power (hazardous areas) without the need for tools.
  - C. Sensor modules shall contain all relevant sensor information within the module so that the module may be calibrated off site. This information shall include sensor manufacturer date, gas type, gas range, calibration data, and default relay parameters. The sensor module shall not require a battery or power source to store this data.
  - D. Then sensor shall be capable of being mounted remotely from the transmitter. The allowable distance from the remote mounted sensor to the transmitter shall be a minimum of 100 feet. The enclosure for the combustible gas sensor shall be classified as Class I, Division 1, Groups A, B, C & D.

### 2.03 TRANSMITTER

- A. The transmitter shall be classified as Class I, Division 1, Groups B, C & D. The transmitter shall have a digital readout to indicate the gas type being monitored and the concentration of gas present. The display shall sequentially show the gas type and gas concentration. The transmitter shall have normal, alarm, and fault indicating lights. Alarm level set points shall be adjustable by means of a hand-held infrared controller.
- B. Transmitters shall have the following specifications:

<b>Temperature Range</b>	-40°C to +60°C
<b>Drift</b>	Zero drift, <5% per year Span drift, <10% per year
<b>Accuracy</b>	±1% Full scale or 2ppm, typical ±2% Full scale or 2ppm, (O <sub>2</sub> , CO) ±3% Full scale (<50% LEL combustibles) ±5% Full scale (>50% LEL combustibles) ±10% Full scale or 2ppm (non-CO toxics)
<b>Response Times</b>	<12 sec., for 20% change (oxygen and toxics) <30 sec., for 50% change (oxygen and toxics) <8 sec., for 50% change (combustibles) <20 sec., for 90% change (combustibles)
<b>Humidity</b>	15%-95% relative humidity, non-condensing

<b>Sensor Life</b>	2 years (oxygen and toxics) 3 years (combustibles)
<b>Power</b>	90 - 130 VAC, 50-60 Hz (internal power supply)
<b>Signal Output</b>	4-20 mA 2-wire current sink 4-20 mA 3-wire current source
<b>Relay Contacts</b>	Rating, 5 amp @ 220 VAC; 5 amp @ 30 VDC

- C. Calibration shall be performed by a hand-held infrared controller. It shall not be necessary to open the monitor enclosure to perform calibration or adjustment of the unit. With the exception of a monthly check and recalibrations, no periodic maintenance shall be necessary.
- D. Gas monitoring systems shall be Ultima X Series as manufactured by MSA Instruments, equivalent by Draeger or Scott, or equal.

### **PART 3 – EXECUTION**

#### **3.01 REQUIREMENTS**

- A. Refer to Section 40 76 21 – Instrumentation for Process Systems.

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**SECTION 40 78 00**  
**PANEL MOUNTED INSTRUMENTS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation the panel mounted instruments, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Control and Information System Scope and General Requirements
- B. Section 40 62 00 – Control and Information System Hardware, General
- C. Section 40 67 00 – Control System Equipment Panels and Racks

**1.03 GENERAL INFORMATION AND DESCRIPTION**

- A. All equipment mounted on the face of a panel shall conform to the same NEMA rating specified for the panel construction.

**1.04 TOOLS, SUPPLIES AND SPARE PARTS**

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts, General. In addition, the following specific spare parts items shall be provided:
  - 1. One of each type of panel mounted equipment (i.e., indicators, signal converters, etc.) provided under this Contract.
  - 2. Five of each type of interposing control relay provided under this Contract.

**PART 2 – PRODUCTS**

**2.01 OPERATORS**

- A. Control operators shall be 30.5 mm, round, heavy-duty, oil tight NEMA 4X corrosion resistant. For Hazardous areas, control operators shall be rated NEMA 7.

- B. Pushbuttons shall be non-illuminated, spring release type. Pushbuttons shall include a full guard. Panic stop/alarm pushbuttons shall be red mushroom type with manual-pull release. Selector switches shall be non-illuminated, maintained contact type, unless otherwise indicated.
- C. Pilot lights shall be of the proper control voltage, push-to-test LED type with lens and LED lamp colors as specified below.
  - 1. Red: stopped, off, or closed
  - 2. Green: running, on, or opened
  - 3. Amber: fault, alarm, or warning
  - 4. White: generic non-alarm status
  - 5. Blue: control power on
- D. Control operators shall have legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Engraved nameplates shall be securely fastened above each control operator. If adequate space is not available, the nameplate shall be mounted below the operator.
- E. Control operators for all equipment under this Contract shall be of the same type and manufacturer unless otherwise indicated. Control operators such as pushbuttons (PB), selector switches (SS), and pilot lights (PL) shall be Cutler-Hammer/Westinghouse Type E34, Square D Company Type SK, or equal

**2.02 ELECTRONIC INDICATORS**

- A. Electronic indicators shall be 3.5 or 6 digit, as appropriate, with 0.56" high red LED display. Indicators shall be provided with nameplate and scale calibrated to match the calibration of the primary element. The unit shall be designed primarily for use with 4-20 mA current loop signal circuits. Indicator operating voltage shall be 115 VAC 10%, 60 Hz. Indicator controls shall include three (3) front-panel pushbuttons for modifying alarm values and other indicator setup. Two (2) form-C relays shall be provided for each indicator. Relay contact outputs shall be rated 5A, 120/240 VAC, resistive load. Where required, a regulated and isolated 24 V excitation power supply shall be provided. Indicators shall be suitable for indoor or outdoor service as required and shall have the same NEMA enclosure rating as the associated enclosure.
- B. Indicators shall be Red Lion Model IMP or APLCL, Precision Digital, or equal.

**2.03 RELAYS**

A. Interposing control relays (CR)

1. Where required to interface between motor control centers, equipment controls, and control panels, interposing relays and associated control wiring circuitry shall be furnished and installed to provide the monitoring and/or control functions specified herein.
2. Interposing relays shall be small format type, DPDT, minimum 10 amp, 120 VAC contact rating.
3. Relay coils shall be 120 VAC or 24 VDC as required to interface with equipment.
4. Relays shall have a flag indicator to show relay status, a pushbutton to allow manual operation of the relay, and an internal pilot light to indicate power to the coil.
5. Relays shall be as manufactured by Square D, Potter & Brumfield, Allen-Bradley, or equal.

B. Timing Relays (TR)

1. Timing relays shall be electronic type with 120 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with a minimum of two SPDT timed output contacts and instantaneous contacts where required. Contact ratings shall be the same as for interposing relays.
2. Timing relays shall be the general purpose plug-in type, Type JCK as manufactured by Square D Company, equivalent by Eaton/Cutler-Hammer, equivalent by Allen-Bradley, or equal.

**2.04 TOTALIZERS**

- A. Totalizing counters shall be provided for flush panel, spring-clip mounting. Face dimensions of the totalizing counters shall be no larger than 1-1/8-inches high by 2-inches wide. Totalizing counters shall contain eight digits. Height of the digits shall not be less than 5/32-inch. Numerals shall be white on a black background. The counter shall be non-resettable and shall be totally compatible for operation on the pulses supplied by the associated instrument or integrator. The totalizing counter shall be capable of a maximum count rate of 25 counts/second.
- B. Legend plates shall be provided for each of the totalizing counters with white letters on a black background with legends as specified below.
- C. Totalizing counters shall be manufactured by Kessler-Ellis, or equal.

## **2.05 ALARM HORNS**

- A. Alarm horns shall be general-purpose type, panel-mounted, and shall be suitable for indoor or weatherproof service, as required. Power supply shall be either 115 VAC or 24 VDC. Horns shall be capable of producing 100 dB at 10 feet and shall have adjustable volume.
- B. Horns shall be Vibratone series as manufactured by Federal Signal Corporation, McMaster-Carr equivalent, Edwards Signaling Company equivalent, or equal.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. Refer to Section 40 67 00 – Control System Equipment Panels and Racks, for additional requirements.

**END OF SECTION**



## SECTION 40 78 56

### ISOLATORS, INTRINSICALLY-SAFE BARRIERS, AND SURGE SUPPRESSORS

#### PART 1 – GENERAL

##### 1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, and place in satisfactory operation the isolators, intrinsically-safe barriers, and surge protection devices (SPDs) as specified herein and as shown on the Drawings.

##### 1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Control and Information System Scope and General Requirements
- B. Section 40 62 00 – Control and Information System Hardware, General
- C. Section 40 67 00 – Control System Equipment Panels and Racks
- D. Section 40 78 00 – Panel Mounted Instruments

##### 1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts, General.
- B. In addition, the following specific spare parts items shall be provided:
  - 1. Five of each type of surge protection device provided under this Contract.

#### PART 2 – PRODUCTS

##### 2.01 SURGE PROTECTION

- A. General
  - 1. All electrical and electronic elements shall be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical systems.
  - 2. Manufacturer's Requirements: All surge protection devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Acceptable manufacturers shall be Phoenix Contact, Edco, Transtector, Weidmuller, or equal.

3. Surge protection device installations shall comply with UL 94, the National Electric Code (NEC), and all applicable local codes.
4. Surge protection devices shall be installed as close to the equipment to be protected as practically possible.
5. Device Locations: As a minimum, provide surge protection devices at the following locations:
  - a. At connections between AC power and electrical/electronic equipment, including, but not limited to, panels, assemblies, and field mounted analog transmitters.
  - b. At both ends of analog signal circuits that have any portion of the circuit extending outside of a building.
  - c. At both ends of copper-based communication cables which extend outside of a building, including at field instruments and the field side of analog valve position signals.
  - d. On all external telephone communication lines.

B. AC power protection

1. Surge protection device assemblies for connections to AC power supply circuits shall:
  - a. Be provided with two 3-terminal barrier terminal strips capable of accepting No. 12 AWG solids or stranded copper wire. One terminal strip shall be located on each end of the unit.
  - b. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements. The surge protection device shall be provided with provisions for mounting to interior of equipment racks, cabinets, or to the exterior of freestanding equipment.
  - c. Be constructed as multistage devices consisting of gas tube arrestors, high energy metal oxide varistors, or silicon avalanche suppression diodes. Assemblies shall automatically recover from surge events and shall have status indication lights.
  - d. Comply with all requirements of UL 1449, latest edition.
  - e. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

- f. Have the following characteristics:
  - 1) Maximum Continuous Operating Voltage: 150VAC
  - 2) Maximum Operating Current: 20 amps
  - 3) Ambient Temperature Range: -20 degrees C to +65 degrees C
  - 4) Response Time: 5 nanoseconds

C. Analog signal circuit protection

- 1. Surge protection device assemblies for analog signal circuits shall:
  - a. Have four lead devices with DIN Rail mounting.
  - b. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.
  - c. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.
  - d. Comply with all requirements of UL 497B.
  - e. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.
  - f. Limit line-to-line voltage to 40 volts on 24VDC circuits.
  - g. Have the following characteristics:
    - 1) Maximum Continuous Operating Voltage: 28VDC
    - 2) Ambient Temperature Range: -20 degrees C to +65 degrees C
    - 3) Response Time (Line-to-Line): 5 ns

D. Communication circuit protection

- 1. Surge protection devices for copper-based data communication circuits shall:
  - a. Be designed for the specific data communication media and protocol to be protected (e.g., telephone, serial, parallel, network, data highway, coax, twinaxial, twisted pair, RF).

- b. Provide protection of equipment to within the equipment's surge withstand levels for applicable standard test wave forms of the following standards:
  - 1) IEC 60-1 / DIN VDE 0432 part 2
  - 2) CCITT K17 / DIN VDE 0845 part 2
  - 3) IEEE C62.31
- c. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.
- d. Provide automatic recovery.

## **2.02 INTRINSICALLY SAFE BARRIERS AND RELAYS**

- A. Intrinsically safe relays and barriers shall be provided where required to interface with equipment located in Classified (i.e., hazardous) areas.
- B. Intrinsically safe relays and barriers shall be FM approved.
- C. Manufacturer shall be
  - 1. Pepperl+Fuchs
  - 2. Crouse Hinds
  - 3. Square D
  - 4. Or equal.

## **2.03 ISOLATORS AND CONVERTERS**

- A. Signal converters shall be provided as required to provide control functions and to interface instrumentation and controls, equipment panels, motor control centers and other instrumentation and controls supplied under other Divisions to the controls provided herein.
- B. General Requirements
  - 1. Converters shall be of the miniature type, utilizing all solid-state circuitry suitable for mounting within new or existing cabinetry. Where sufficient cabinet space is not available, sub panels or supplemental enclosures shall be provided.
  - 2. Power supply shall be 120V, 60 hertz where required by the converter, unless otherwise indicated.

3. Repeatability shall be 0.1% of span, deadband shall be 0.1% span, maximum.
4. Where specific converters are not listed, but are required to interface with the process control system, they shall comply with the general requirements stated herein.

C. Current to Current (I/I) Isolators

1. Current to current isolators shall be furnished where necessary to provide an isolated current loop, calculations or signal amplification between the plant process control system and instrumentation and control loops. Isolators shall be sized such that resistance of existing loops shall not exceed maximum rated resistance.
2. Isolators shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

D. Voltage to Current (E/I) Transducers

1. Voltage to current (or current to voltage) transducers shall convert a voltage signal of one magnitude to a 4 20 milliamp DC current signal. The output current shall be directly proportional to the input signal voltage. Transducers shall be sized such that loop resistance does not exceed maximum rated resistance.
2. Transducers shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

E. Frequency to Current (F/I) Transducers

1. Frequency to current transducers shall convert pulse rate and pulse duration signals to 4 20 mA, 24 VDC analog signals. Converters shall include field adjustable input frequency range. Converter power shall be 120 VAC, 60 hertz. Transducers shall be sized such that loop resistance does not exceed maximum rated resistance. Transducers shall be suitable for signal transmission via leased telephone lines.
2. Transducers shall be Series 5100 as manufactured by AGM, or equivalent by Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

F. Current to Frequency (I/F) Transducers

1. Current to frequency transducers shall convert 4 20 mA, 24 VDC analog signals to pulse rate and pulse duration signals. Converters shall include field adjustable output frequency range. Converter power shall be 120 VAC, 60 hertz. Transducers shall be sized such that loop resistance does not exceed maximum rated resistance. Transducers shall be suitable for signal transmission via leased telephone lines.

2. Transducers shall be Series 5016 as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

#### G. Integrators

1. Integrators shall be provided as interchangeable plug in modules with zero and span adjustment available on the front plate of the units. Output shall range from 0 to 0.1 through 0 to 10 pulses per second. Accuracy shall be + 0.1% of input span. Integrators shall convert linear analog signals to pulse rate and provide a solid state output.
2. Integrators shall be as manufactured by AGM Electronics, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

#### H. Electronic Switches (Alarm Relays)

1. Electronic switches shall be furnished with a calibrated dial for adjusting set points. The input to the switch shall be 4 - 20 mA DC, and the set point shall be adjustable over the full range. Unless otherwise noted, the dead band shall be fixed at less than 2% of span. The set point stability shall be +0.1% per degree F. The repeatability shall be +0.1% of span. The units shall be furnished with SPDT relays rated at 10 amperes at 115 VAC.
2. Electronic switches shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

#### I. RTD to Current Signal Converters

1. RTD to current signal converters shall convert a 3-wire RTD input signal to an isolated 4 20 mADC output signal. Accuracy shall be 0.10% of span or better. Calibrated span of each converter shall be as indicated on the instrument list. The Contractor shall coordinate calibration of the signal converters with existing RTD elements.
2. Signal converters shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

## **PART 3 – EXECUTION**

### **3.01 REQUIREMENTS**

- A. See Section 40 78 00 – Panel Instruments and Accessories, for additional requirements.

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**SECTION 40 78 59**  
**POWER SUPPLIES**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation all power supplies, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.
- B. All power conditioners shall be mounted within consoles or control panels containing the associated digital equipment unless otherwise specified or shown on the Drawings.
- C. One power conditioner shall be provided for each PLC cabinet provided under this Contract.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 62 00 – Computer System Hardware and Ancillaries
- C. Section 40 63 43 – Programmable Logic Controllers

**PART 2 – EQUIPMENT**

**2.01 POWER CONDITIONERS**

- A. Each power conditioner shall be sized to match the maximum power requirements of the associated digital equipment, control panel power supplies and accessories.
- B. Each power conditioner shall meet the following requirements:
  - 1. Input voltage shall be 120 VAC, single phase, 60 Hz.
  - 2. Voltage regulation shall be  $\pm 3\%$  for line changes of +10%/-20%.
  - 3. Total harmonic distortion shall be less than 3% of RMS.
  - 4. Ambient operating temperature shall be from -20 to 50 degrees C.
- C. Power conditioners shall be Sola Model MCR, or equal.

**PART 3 – EXECUTION**

**3.01 REQUIREMENTS**

- A. Refer to Section 40 61 13 – Process Control System General Provisions.

**END OF SECTION**

**SECTION 40 79 00**  
**MISCELLANEOUS INSTRUMENTS, VALVES, AND FITTINGS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, test, install and place in satisfactory operation, the instrumentation and control system accessories with all spare parts, and appurtenances as herein specified and as shown on the Drawings.
- B. Accessories include various items of equipment that may be required in the system but are not scheduled. Accessories are shown on details, flow sheets or plans. Accessories are also called out in specifications for scheduled instruments and in the installation specifications. It is not intended, however, that each piece of hardware required will be specifically described herein. This Specification shall be used as a guide to qualify requirements for miscellaneous hardware whether the specific item is described or not.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

**1.03 SUBMITTALS**

- A. Per Section 40 61 15 – Process Control System Submittals
- B. Impulse piping layout and routing drawings
- C. Complete instrument assembly drawings showing orientation to installed process piping.

**PART 2 – PRODUCTS**

**2.01 PROCESS TUBING**

- A. Process, impulse, or capillary tubing shall be 1/2 x 0.065-inch seamless, annealed, ASTM A-269 Type 316L stainless steel with 37 degrees Type 316 stainless steel flared fittings or Swagelock or Parker-CPI flareless fittings.
- B. Piping for closely coupling instruments to process seals shall be standard stainless steel NPT threaded piping or NPT tapped mounting blocks.
- C. A nickel-based lubricant shall be used on threaded stainless steel piping connections to prevent galling.

## **2.02 POWER, CONTROL, AND SIGNAL CABLES**

- A. Power, control and signal wiring shall be provided under Division 26 of the Specifications, unless otherwise indicated.

## **2.03 CHEMICAL DIAPHRAGM SEALS**

- A. Diaphragm seals shall be provided for isolation of pressure gauges, switches and transmitters attached to systems containing chemical solutions or corrosive fluids. As a minimum, seals shall be of all 316 stainless steel construction. In general, diaphragms shall be 316L stainless steel for operating pressures at or above 15 psi and elastomers for operating pressures below 15 psi. However, all components shall be non-reactive with the process fluid in all cases. Refer to the Process Control System Instrument Lists for specific materials requirements.
- B. Seal shall have fill connection, 1/4-inch NPT valved flush port and capable of disassembly without loss of filler fluid. Where specified, diaphragm seals shall comply with the above requirements and shall be provided with 316 SS factory filled capillaries.
- C. Seals shall be Helicoid Type 100 HA, Mansfield & Green, Ashcroft, or equal.

## **2.04 ISOLATING RING SEALS**

- A. For solids bearing fluids, line pressure shall be sensed by a flexible cylinder lining and transmitted via a captive sensing liquid to the associated pressure sensing instrument(s).
  - 1. Full Line Size Isolating Ring Seals
    - a. Where indicated, the sensor body shall be full line size wafer design.
    - b. Full line size isolating ring seals shall have 316 stainless steel housing and assembly flanges and Buna N flexible cylinder lining for in line mounting. The wafer shall have through bolt holes or centerline gauge for positive alignment with the associated flanged piping. Gauge or readout shall be oriented for viewing.
    - c. The captive liquid chamber and associated instrument(s) shall be furnished with threaded drain tap and plug. Manufacturer shall furnish seals with a quick-disconnect-type fitting for field disassembly and reassembly, however, seal and instruments shall be factory assembled prior to arriving at the job site
    - d. Isolating ring seals shall be RED Valve Series 40, Ronningen Petter Iso Ring, Moyno RKL Series W, Onyx Isolator Ring, or equal.
  - 2. Tapped Isolating Ring Seals

- a. Where indicated, pressure shall be sensed via a minimum 1-1/2" diameter spool type isolating ring seal mounted on a 1-1/2" pipe nipple at 90 degrees from the process piping.
- b. An isolation ball valve shall be provided between the process piping and the ring seal, and a cleanout ball valve shall be provided between the ring seal and the atmosphere. The factory assembled and filled pressure instrument shall be back or side mounted to the ring seal such that the gauge or readout may be viewed normally.
- c. Tapped isolating ring seals for solids service shall be Red Valve Series 42/742, Ronningen Petter Iso Spool, Onyx Isolator Ring, or equal.

## **2.05 FILLING MEDIUM:**

- A. The filling medium between instruments, isolating ring seals and diaphragm seals shall be a liquid suitable for operation in an ambient temperature ranging from -10 degrees F to +150 degrees F.
- B. Filling medium shall be silicone unless oxidizing agents, such as sodium hypochlorite, are present, then halocarbon shall be used.

## **2.06 TAMPER EVIDENT PAINT**

- A. Piping and screwed/bolted connections of instrumentation containing the filling medium shall be marked with a small continuous tick mark of tamper evident paint over each piping/instrument joint. Tamper evident paint shall be applied prior to instrument assemblies arriving on the job site. Disturbance of the joint shall break the paint.
- B. Instrument assemblies with broken paint or missing paint shall not be accepted and shall be repaired or replaced at no additional cost to Owner. Paint shall be Dykem Cross-Check or equal.

## **2.07 ISOLATION VALVES**

- A. Isolation valves shall be 1/2 inch diameter ball valves, unless otherwise indicated, with a Type 316 stainless steel body, Type 316 stainless steel ball. Where 316 stainless steel is not compatible with the process fluid, materials of construction shall be suitable for the associated process fluid (e.g., PVC for chemical service).

## **2.08 ALARM ANNUNCIATION DEVICE**

- A. Sirens:
  - 1. For Class I, Division 2 areas and non-hazardous areas:

- a. Provide NEMA 4X and Class I, Division 2 rated alarm horn capable of 32 selectable warning tones. Coordinate tone selection with Owner. Volume shall be field adjustable between 0 and 114 dBA measured at 10 feet.
  - b. Alarm horn shall be the SelecTone 302GCX series with UTM tone module as manufactured by Federal Signal Corporation.
2. For Class I, Division 1 areas:
- a. Provide NEMA 4X and Class I, Division 1 rated alarm horn capable of 32 selectable warning tones. Coordinate tone selection with Owner. Volume shall be field adjustable between 0 and 114 dBA measured at 10 feet.
  - b. Alarm horn shall be the SelecTone 302X series with UTM tone module as manufactured by Federal Signal Corporation.
- B. Strobe Lights:
- 1. Strobes located within the same room, or otherwise visible from any shared frame of view, shall be synchronized per the requirements of NFPA 72. Strobes shall be synchronized by the strobe manufacturer's synchronization module. Strobe circuits shall not exceed the continuous duty current rating of the synchronization module. Synchronization module shall be Federal Signal Model SSM, Edwards Signaling Model EG1M-RM, or equal.
  - 2. For Class I, Division 2 areas and non-hazardous areas:
    - a. Provide red strobe status indicator. Unit shall be rated NEMA 4X and Factory Mutual approved for a Class I, Division 2, Group D area. Unit shall contain a durable polycarbonate housing and be surface mount. Unit shall be UL listed. Strobe shall be powered from 24VDC.
    - b. Alarm strobe shall be Federal Signal Model 225XST, Edwards Signaling Model 116DEGEX-FJ, or equal.
  - 3. For Class I, Division 1 areas:
    - a. Provide red explosion proof dome covered strobe unit rated NEMA 4X and Factory Mutual certified for a Class I, Division 1, Group D area. Unit shall be UL listed. Strobe shall be powered from 24VDC.
    - b. Alarm strobe shall be Federal Signal Model 27XST, Edwards Signaling Model 116DEGEX-FJ, or equal. Compatible mounting hardware by the strobe manufacturer shall be furnished.
  - 4. Lens color shall be as indicated on the Instrument List.

**PART 3 – EXECUTION**

**3.01 REQUIREMENTS**

- A. Refer to Sections 40 70 00 – Instrumentation for Process Systems.

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**SECTION 43 20 00**  
**PUMPS – GENERAL**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, test, and make fully operational all pumping equipment, complete with all necessary accessories, in compliance with the Contract Documents.
- B. All pumping equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.
- C. The provisions of this section shall apply to all pumps and pumping equipment specified except where specifically noted otherwise in the Contract Documents.
- D. The pumps shall be provided complete with all accessories, shims, sheaves, couplings, and other appurtenances as specified, and as may be required for a complete and operating installation.

**1.02 SHOP DRAWINGS**

- A. Shop Drawings shall include the following information in addition to the requirements of Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions.
  - 1. Details of shaft sealing system
  - 2. Pump performance curves at rated speed and reduced speed (if reduced speeds are specified). Curves shall indicate flow, head, efficiency, brake horsepower, NPSH required, and minimum submergence. Curves shall identify minimum continuous stable flow (minimum flow to avoid suction recirculation), preferred operating region (POR) and allowable operating region (AOR) per the latest version of ANSI/HI 9.6.3.
  - 3. General cutaway sections, materials, dimension of shaft projections, shaft and keyway dimensions, shaft diameter, dimension between bearings, general dimensions of pump, suction head bolt orientation, and anchor bolt locations and forces.
  - 4. Foundry certificates and results of Brinnell hardness testing showing compliance to ASTM A 532 (where required in the individual pump specifications).

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5. Submersible pump submittals shall also include:
  - a. Product data sheets for power and control cables and length of cables.
  - b. Details on pump guide rail system and mounting requirements.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

- A. All materials employed in the pumping equipment shall be suitable for the intended application. Material not specifically called for shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements unless otherwise specified in individual pumping equipment Specifications:
  1. Cast iron pump casings and bowls shall be of close-grained gray cast iron, conforming to ASTM A 48, or equal.
  2. Bronze pump impellers shall conform to ASTM B 584, “G” bronze.
  3. Stainless steel pump shafts shall be of Type 400, Series. Miscellaneous stainless steel parts shall be of Type 316.
- B. Suction and discharge flanges shall conform to ANSI standard B16.1 or B16.5 dimensions.

### **2.02 APPURTENANCES**

- A. Pressure Gauges
  1. Contractor shall supply all pressure gauges by one manufacturer The Contractor shall furnish and install pressure gauges on the suction and discharge of each pump, except wet-pit submersible pumps and vertical turbine pumps.
  2. The Contractor shall furnish and install pressure gauges on the discharge piping of each wet-pit submersible pump and vertical turbine pump in the locations shown on the Drawings or as directed by the Engineer.
  3. Suction gauges shall be of the single scale compound type to indicate both pressure and vacuum. Each suction gauge shall be graduated in feet of water over the span of 34 feet below and above zero.
  4. Discharge gauges shall be graduated in feet from zero to a minimum of five (5) feet of water above the respective pump shutoff head or to a minimum of 30%

above the maximum operation pressure, whichever is greater. Graduation shall be in feet of water.

5. All gauges shall be supplied by one manufacturer and shall be as specified in Section 40 73 13 – Pressure and Differential Pressure Gauges.
  6. All gauges shall be provided with diaphragm seals or isolating ring seals as specified in Section 40 79 00 – Miscellaneous Instruments, Valves and Fittings.
- B. Flexible couplings for direct driven pumps shall be as manufactured by Falk, Dodge, Woods Corp., or equal and shall be furnished with guards in accordance with OSHA Rules and Regulations. Spacer couplings shall be provided where necessary to allow removal of the pump rotating element without disturbing the driver.

### **2.03 ELECTRICAL REQUIREMENTS**

- A. All pumps shall be furnished with motors such that the motor shall not be overloaded throughout the full range of the pump operation, unless otherwise specifically approved by the Engineer.
- B. Motor starters and controls shall be furnished and installed under Division 26 and Division 40 unless otherwise specified in the individual pump specifications.

### **2.04 EQUIPMENT IDENTIFICATION**

- A. In addition to the requirements of Section 46 00 00 – Equipment General Provisions, nameplate data for each pump shall include the rating in gallons per minute, rated head, speed, and efficiency at the primary design point.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Drains: All gland seals, air valves, and drains shall be piped to the nearest floor drain or trench drain with galvanized steel pipe or copper tube, properly supported with brackets.
- B. Solenoid Valves: Where required, the pump manufacturer shall furnish and install solenoid valves on the seal water or oil lubrication lines. Solenoid valve electrical rating shall be compatible with the motor control voltage and shall be furnished complete with all necessary conduit and wiring installation from control panel to solenoid.

### **3.02 SHOP TESTING**

- A. Shop tests shall be performed in accordance with Section 46 00 00 – Equipment General Provisions, and except where stated otherwise herein, shall be conducted in accordance with the latest version of Hydraulic Institute Standard 14.6, Hydraulic

Performance Acceptance Tests. For submersible pumps, testing shall be conducted in accordance with the latest version of ANSI/HI 11.6.

- B. Pump rating point shall be within the tolerances specified for Acceptance Grade 1U unless otherwise specified in the individual pump specifications.
- C. Pump shop testing shall be witnessed by the Owner/Engineer where specified in the individual pump specifications. The testing procedure shall be submitted to the Engineer for review before scheduling the testing. The Engineer shall be given at least 2 weeks advanced notice of the scheduled testing date.
- D. Certified test curves shall be provided for all centrifugal pumps unless otherwise specified in the individual pump specifications. Certified tests will not be required for submersible sump pumps with motors less than 5 hp. Certified curves shall identify minimum continuous stable flow (minimum flow to avoid suction recirculation), preferred operating region (POR) and allowable operating region (AOR) per the latest version of ANSI/HI 9.6.3.
- E. For wet pit submersible pumps and vertical turbine pumps, all tests shall be run at minimum pump submergence specified in the individual pump specifications.
- F. Where required in the individual pump specifications, each individual casting shall be Brinnell tested in a minimum of two places, in an area of representative casting thickness to ASTM Method E-10. Results shall be certified by a registered professional ENGINEER. Test results shall verify the satisfaction of the required Brinnell hardness of the finished product as specified in respective subsections.

### **3.03 FIELD TESTING**

- A. Field tests shall be performed in accordance within Section 46 00 00 – Equipment General Provisions and additionally as specified below and in the individual pump specifications.
- B. Final acceptance tests shall demonstrate the following:
  - 1. The pumps have been properly installed and are in proper alignment.
  - 2. The pumps operate without overheating or overloading of any parts and without objectionable vibration. Vibration shall be within the limits identified in the latest version of ANSI/HI 9.6.4, or manufacturer's limits if more stringent. For wet pit and dry pit submersible pumps, vibration shall be within the limits identified in the latest version of ANSI/HI 11.6, or manufacturer's limits if more stringent.
  - 3. The pumps can meet the specified operating conditions. All pumps shall be checked at maximum speed for a minimum of four points on the pump curve for capacity, head, and amperage. The rated motor nameplate current shall not be

exceeded at any point. Pumps with drive motors rated at less than five horsepower shall only be tested for overcurrent when overheating or other malfunction becomes evident in general testing.

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**SECTION 43 25 13**  
**SUBMERSIBLE NON-CLOG PUMPS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish and install submersible non-clog pumps at the locations shown on the Drawings and as specified herein. All pumps shall be supplied by the same manufacturer.
  - 1. Two submersible pumps shall be fully installed in this contract.
  - 2. A third discharge base shall be installed in this contract.
  - 3. A third submersible pumps and power cable shall be purchased and delivered to CCWA.
- B. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pump – General.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Section 40 63 43, Programmable Logic Controllers (PLC)
- B. Section 40 67 00, Control System Equipment Panels and Racks
- C. Section 40 72 76.13, Multiple Point Level Switches
- D. Section 40 72 76.26, Level Switches (Floats)
- E. Section 40 73 13, Pressure and Differential Pressure Gauges

### 1.03 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

#### Submersible Pumps No. 1 – No. 2

Number of Units	2
Design Capacity (gpm)	1,000
Total Dynamic Head (feet)	168
Maximum Brake Horsepower	70
Maximum Pump Speed (rpm)	1800
Temperature of Liquid Pumped	Ambient
Suction Condition	Flooded
Maximum Size of Solids (Spherical Diameter, Inches)	3
Minimum Discharge Diameter (In.)	4

### 1.04 SUBMITTALS

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures; and Section 46 00 00 – Equipment General Provisions:
1. Shop Drawings
  2. O&M Manuals

## PART 2 – PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Each pump shall be a submersible, non-clog, centrifugal pump, as manufactured by Flygt, Sultzzer/ABS, KSB, Homa or equal.

### 2.02 MATERIALS

- A. The pump and all related equipment shall be designed for the wastewater applications specified herein and shall be suitable for continuous or intermittent operation. The pump shall be bottom suction, side discharge construction and shall be supplied with a foot mounted discharge connection elbow and integral sliding rail removal system of the pump manufacturer's design matched to the pumps being supplied.



- B. The lifting cover, stator housing, and volute casing shall be close-grained cast iron conforming to ASTM A48-Class 30, 35, or 40. Ductile iron pump volute shall be furnished if recommended by pump manufacturer for specified pressure rating. All exposed nuts, bolts, washers, and other fastening devices shall be AISI type 316 stainless steel.
- C. Casing shall be a smooth surface devoid of blowholes, pits, burrs, or other irregularities. The casing shall have a suction cover, which can be easily removed for easy access to the impeller. All non-stainless steel metal surfaces coming in contact with the pumped media shall be protected by a factory applied spray coating of Supplier's modified acrylic primer and finish. The volute shall be single piece, non-concentric design and shall have smooth fluid passages large enough at all points to pass any size solids which can pass through the impeller. Pump volute shall be provided with a cleanout port to allow for removal of any foreign material blocking or impeding performance of the pump.
- D. All mating surfaces where watertight sealing is required shall be machined and fitted with nitrile or Viton rubber O-rings. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces. This will result in controlled compression of the O-rings without the requirement of a specific torque limit. Secondary sealing compounds, rectangular gaskets, elliptical O-rings, grease or other devices shall not be acceptable.
- E. The impeller shall be hard alloy gray cast iron conforming to ASTM A-48 Class 30, 35, or 40. Impellers shall be dynamically balanced, closed non-clogging design with multiple vanes. The impeller shall be capable of handling solids of specified sphere size, fibrous materials, heavy sludge, and other matter found in normal wastewater applications. The impeller shall be mechanically secured to the motor shaft per manufacturer's recommendations utilizing machined stainless steel components. Adhesive or friction-type fits are not acceptable. Impeller shall be coated with the same system applied to the interior of the casing.
- F. A wear ring system shall provide efficient sealing between the volute and impeller. Casing and impeller wear ring shall be of stainless steel construction. Supplier shall submit AISI grades of stainless steel proposed for the wear rings. Rings shall be drive fitted to the volute inlet and heat-shrink fitted to the impeller.
- G. Shafting shall be constructed of AISI 329 stainless steel or 400 Series stainless steel for the pump and motor, sufficiently large in diameter to transmit safely the maximum torque developed by the drive unit and of such a design as to provide a rigid support for the impeller and to prevent excessive vibration. The shaft shall be suitably heat-treated, turned, ground, and polished over its entire length.
- H. Shaft Seals
  - 1. Each pump shall be provided with a tandem mechanical shaft seal system consisting of two totally independent seal assemblies of high-pressure design. The

seals shall operate in a lubricant reservoir that hydrodynamically lubricates the lapped seal faces at a constant rate. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity. The drain and inspection plug, with positive anti-leak seal shall be easily accessible from the outside. The seal system shall not rely upon the pumped media for lubrication. Seal lubricant shall be FDA Approved, nontoxic.

2. The lower, primary seal unit, located between the pump and the lubricant chamber shall contain one stationary and one positively driven rotating, industrial duty, corrosion resistant, seal rings (Tungsten carbide/Tungsten carbide or Tungsten carbide/silicon carbide). The lower seal shall be independent of the impeller hub.
  3. The upper, secondary seal unit, located between the lubricant chamber and the motor housing, chamber shall contain one stationary and one positively driven rotating, industrial duty, corrosion resistant, seal rings (ceramic/carbon or carbo/Ni-resist).
  4. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment and shall be capable of operating in either clockwise or counter clockwise direction of rotation without damage or loss of seal. The seal system shall not be damaged when run dry. No external source of seal cooling or lubrication water shall be required.
  5. The following seal types shall not be considered acceptable nor equal to the dual independent seal specified: shaft seals without positively driven rotating members, or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces. Cartridge type systems will not be acceptable. No system requiring a pressure differential to offset pressure and to effect sealing shall be used.
- I. The pump shaft shall rotate on at least two (2) heavy duty permanently lubricated bearings. Bearings shall be designed to carry all radial and axial thrust loads and shall have a minimum AFBMA B-10 life of 100,000 hours at all points along the usable portion of the pump curve at maximum pump speed.
  - J. Each pump, as specified herein or as recommended by the manufacturer, shall be provided with an integral, self-supplying cooling system that is adequately designed to cool the motor without an external cooling source. The cooling jacket shall be of cast-iron construction and shall surround the stator housing. The cooling jacket shall provide heat dissipation for the motor regardless of whether the motor unit is submerged in the pumped media or surrounded by air. The impeller back vanes shall provide the necessary circulation of the cooling liquid, a portion of the pumpage, through the cooling system. The cooling liquid shall pass through a classifying labyrinth prior to entering the cooling jacket. Two cooling liquid supply pipes, one discharging low and one discharging high within the jacket, shall direct the cooling liquid to the jacket. An air evacuation tube shall be provided to facilitate air removal from within the jacket. Any piping internal to the

cooling system shall be shielded from the cooling media flow allowing for unobstructed circular flow within the jacket about the stator housing. Two cooling liquid return ports shall be provided. The internals to the cooling system shall be non-clogging by virtue of their dimensions. Drilled and threaded provisions for external cooling and, seal flushing or air relief are to be provided. The cooling jacket shall be equipped with two flanged, gasketed and bolted inspection ports of not less than 4" diameter located 180° apart. The cooling system shall provide for continuous submerged or completely non-submerged pump operation in liquid or in air having a temperature of up to 40°C (104°F), in accordance with NEMA standards. Restrictions limiting the ambient or liquid temperatures at levels less than 40°C are not acceptable.

- K. Gauge taps shall be provided on the discharge piping of the vertical submersible pumps in a location as directed by the Engineer. Gauge taps shall be threaded corporation stops, conforming to the requirements of Section 40 05 00 – Basic Mechanical Requirements. Gauges shall be as specified in Section 40 73 13 – Pressure and Differential Pressure Gauges.
- L. The Slide Rail Mounting System shall be as shown on the Contract Drawings and as specified herein.
  - 1. A rail system shall be provided and installed for each pump. The pump shall be easily removed from the wetpit for inspection or service without entering the pit or disconnecting piping.
  - 2. The pump shall be provided with a foot mounted discharge connection elbow constructed of cast iron conforming to ASTM A48-Class 30 or 35, permanently installed in the wet well along with the discharge piping. The discharge connection elbow shall be constructed with a 125 lb. ANSI standard flat faced flange. The pump shall be automatically connected to the discharge connection elbow when lowered into place, and shall be easily removed for inspection or service. Sealing of the pumping unit to the discharge connection elbow shall be accomplished by a simple downward motion of the pump.
  - 3. A sliding guide bracket shall be an integral part of the pump unit. The entire weight of the pump unit shall be guided by the guide bar(s) and pressed tightly against the discharge connection elbow to provide positive sealing under all conditions.
  - 4. The entire sliding rail system shall be designed to safely withstand all stresses imposed thereon by vibration, torque, shock and all possible direct and eccentric loads. No portion of the pump shall bear directly on the floor of the sump.
  - 5. Lower guide bar holders shall be integral with the discharge connection. Guide bars shall be of at least standard weight 316 stainless steel pipe of a conservative size adequate for its intended use. The guide bars shall not support any portion of the weight of the pump.

6. All anchor bolts, lifting bolts, eye lugs and lifting cable, etc. necessary for a complete installation and maintenance of the pump shall be constructed of Type 316 stainless steel and shall be adequately designed for its intended use.
  7. All metal to metal interfaces where movement might occur shall be non-sparking. The slide mounting system for the influent pumps shall meet or exceed Underwriters Laboratory requirements for operation in a Class I, Division 1, Group D hazardous location.
- M. All anchor bolts, lifting bolts, eye lugs, etc. necessary for complete installation and maintenance of the pump shall be furnished by Supplier and constructed of Type 316 stainless steel and shall be adequately designed for its intended use.

### **2.03 ELECTRICAL AND CONTROL REQUIREMENTS**

- A. The pump manufacturer shall provide the power and control cables between the pump and the local disconnect switch, junction box, or control panel (see Drawings) and shall be responsible for reviewing the electrical drawings as necessary to determine the required cable length. All pumps for the same pumping application shall be provided with the same length of cable. No splices shall be allowed unless specifically indicated on the Drawings. Cables shall be PVC or oil resistant chloroprene rubber jacketed type SPC cable suitable for submersible pump applications, shall be sized according to NEC and ICEA standards, and shall meet with MSHA approval. Stainless steel strain relief connectors shall be furnished for all cables.
- B. Cable Entry Water Seal
1. The cable entry water seal design shall insure a watertight and submersible seal without specific torque requirements. The cable entry shall be comprised of a single cylindrical elastomer grommet, flanked by stainless steel washers all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable. The assembly shall bear against a shoulder in the pump top. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate gaining access through the pump top. The junction chamber containing the terminal board shall be sealed from the motor by an elastomer compression seal O-ring. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to the terminal board and thus perfectly leak proof. Each pump shall be equipped with separate terminal board that totally isolates the incoming power supply from the pump motor.
  2. An acceptable alternate cable entry seal shall include cable leads shall enter at the top of the motor and shall allow the cable-to-motor connection to be accomplished in the field without soldering. All power and control lead wires shall be double

sealed as they enter the motor in such a manner that cable-wicking will not occur. This sealing system shall consist of a rubber grommet followed by epoxy that is high in adhesive qualities and has a low coefficient of expansion. Each conductor shall have a small section of insulation removed to establish a window area of bare wire and each wire shall be untwisted and surrounded by epoxy potting material. A cable strain relief mechanism shall be an integral part of the sealing system. The cable sealing system shall be capable of withstanding an external pressure test of 1,200 psi as well as a cable assembly pull test as required by Underwriters Laboratories. Power and control leads shall be terminated on a sealed terminal board. The terminal board and its bronze lugs shall be O-ring sealed.

C. Electrical Requirements

Motors	Pumps
Rating	460V, 3 ph, 60 Hz
Maximum Horsepower	70
Speed, rpm	1800
Insulation	Class H
Explosion Proof	Yes
Inverter Duty	No
Service Factor	1.15
Motor Temperature Sensors / Leakage Detector	Yes
RTDs	No
Cooling Jacket	Yes

- D. The pump motor shall be a squirrel-cage induction type, housed in a watertight chamber. The stator winding and stator leads shall be moisture resistant. The use of bolts, pins, or other fastening devices requiring penetration of the stator housing shall not be allowed.
- E. The motor shall be guaranteed for continuous unsubmerged duty, capable of sustaining a minimum of ten (10) starts per hour without overheating.
- F. The motor shall be provided with pre-lubricated radial and thrust bearings which are designed to carry the entire load which may be imposed upon it under all operating conditions.
- G. All motors shall be of nationally known manufacture, shall be housed in enclosures specifically designed for submersible pump application.

- H. Moisture detector probes shall be provided in the oil-seal chamber and temperature sensors shall be provided in the motor stator winding.
- I. The pump manufacturer shall provide pump protection relay(s) to monitor the moisture probe and temperature sensor. The relay(s) shall be installed in the Pump Control Panel.
- J. The pump manufacturer shall provide the following accessories for the pumps:
  - a. Float switches LSSL-103, LSHH-103
  - b. Multi-point level probe system LE/LT-103

## **2.04 CONTROL PANEL**

- A. Provide a pump control panel that interfaces with the SCADA system (furnished by others) and with the motor control center (furnished by others) to control and monitor the pumps. The control panel shall include, but not be limited to, the following:
  - 1. Provide a control panel fully configured for triplex pump operation with the third pump disabled for initial duplex operation.
  - 2. Provide an indoor, NEMA 12, painted steel enclosure, free-standing or fitted for wall mounting.
  - 3. Provide a single, circuit breaker-type, lockable disconnect switch operable from outside the control panel. Power supply: 120 volts, single-phase.
  - 4. Mount control switches, indicating lights, and HMI, if provided, on front door of the control panel.
  - 5. Pump protection relay (furnished by pump manufacturer) for each pump.
  - 6. Control Panel Features:
    - a. Control panel shall be provided with individual operators and indicators mounted on the front of the panel or with an operator interface touchscreen device meeting the requirements of Section 40 62 63, Operator Interface Terminals
    - b. Pump controller or programmable logic controller (PLC)
    - c. Lead 1/Lead 2/Lead 3/Alt alternation handswitch.
    - d. Hand/Off/Auto selector switch for each pump.
    - e. Pump Run indicator light for each pump.
    - f. Pump elapsed run time meter for each pump.

- g. Pump Fail alarm light for each pump.
  - h. High Moisture alarm light for each pump.
  - i. Motor High Temperature alarm light for each pump.
  - j. Alarm Acknowledge pushbutton.
  - k. Level indication (as detected by level probe).
  - l. High Wetwell Level alarm light.
  - m. High High Wetwell Level alarm light.
  - n. Low Low Wetwell Level alarm light.
7. Discrete I/O:
- a. Run command (normally open, dry contact output for interface with motor starter), typical for each pump.
  - b. Pump Run (normally open, dry contact input for interface with motor starter), typical for each pump.
  - c. Pump Fail (normally open, dry contact input for interface with motor starter), typical for each pump.
  - d. Pump Run (normally open, dry contact output for interface with SCADA system), typical for each pump.
  - e. Pump Fail (normally open, dry contact output for interface with SCADA system), typical for each pump.
  - f. Pump High Motor Temperature (normally open, dry contact output for interface with SCADA system), typical for each pump.
  - g. Pump High Moisture (normally open, dry contact output for interface with SCADA system), typical for each pump.
  - h. Wetwell High High Level (normally open, dry contact input from float switch)
  - i. Wetwell Low Low Level (normally closed, dry contact input from float switch)
  - j. Level inputs from the multi-point level switch (maximum ten dry contact inputs)
8. Control Sequence:

- a. Each pump shall be provided with a Hand-Off-Auto (H-O-A) control switch on the front of the control panel. In the Hand mode, the pump shall Run. In the Off mode, the pump shall be stopped. In the Auto mode, the pump's operation shall be controlled by the pump controller based on level in the wetwell.
- b. In the Auto mode, the pumps shall operate in a Lead/Lag configuration based on the position of the alternation handswitch. If the handswitch is in the Alternate position, the Lead pump shall become the Lag pump and the Lag pump shall become the Lead pump for the next pumping cycle when the pump(s) stop on Low wetwell level.
- c. The wetwell elevation control setpoints shall be as shown on the Mechanical drawings.
- d. The Lead pump shall be called to run when the level in the wetwell increases to the Lead Pump On setpoint. The Lead pump shall continue to run alone until either the wetwell level decreases to the All Pumps Off level, when the Lead pump shall stop, or until the wetwell level increases to the Lag Pump On level, when the Lag pump shall be called to run. Both pumps shall run until the level decreases to the All Pumps Off level.
- e. If the wetwell level increases to the High Level Alarm level, the High Level alarm light on the control panel shall be illuminated and a discrete output shall be provided for remote alarm.
- f. If the wetwell level increases to the High High Level Alarm level (float switch), the High High Level alarm light on the control panel shall be illuminated and a discrete output shall be provided for remote alarm.
- g. If the wetwell level decreases to the Low Level Alarm level (multi-point switch and float switch), the Low Level alarm light on the control panel shall be illuminated and a discrete output shall be provided for remote alarm.
- h. If a pump is stopped on a Motor Overtemperature condition, the Motor High Temperature alarm light on the control panel shall be illuminated and a discrete output shall be provided for remote alarm. The alarm indication shall seal-in and remain active until the motor overtemperature condition is corrected and the alarm is manually reset at the control panel.
- i. If a pump is stopped on a Seal Failure condition, the Seal Failure alarm light on the control panel shall be illuminated and a discrete output shall be provided for remote alarm. The alarm indication shall seal-in and remain active until the seal failure condition is corrected and the alarm is manually reset at the control panel.



## 2.05 SPARE PARTS

- A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following for each series of pumps:

1	Set of lower and upper wearing rings
1	Set of motor and pump bearings
1	Complete mechanical seal assembly (upper and lower)
2	Complete set of gaskets and O ring seals

## PART 3 – EXECUTION

### 3.01 MANUFACTURER’S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions. For each series of pumps, field services shall include the following site visits:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

### 3.02 SHOP TESTING

- A. Shop testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:
1. Impeller, motor rating and electrical connections shall be checked.
  2. A motor and cable insulation test for moisture content or defective insulation shall be made.
  3. Prior to submergence, the pump shall be run dry to establish correct rotation and mechanical integrity.
  4. The pump shall be run for 30 minutes submerged, a minimum of six (6) ft. under water.
  5. After the run-dry test, the insulation test shall be performed again.

6. After the run-dry test, the pump shall be run continuously unsubmerged for 2 hours under full load with no damage to the motor. During this test, the pump shall demonstrate compliance with the specified performance for flow, head, and horsepower and shall experience a heat rise of not greater than 45°C (80°F) above ambient temperature.

**END OF SECTION**

**SECTION 46 00 00**  
**EQUIPMENT GENERAL PROVISIONS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, test, and place in acceptable operation all mechanical equipment and all necessary accessories as specified herein, as shown on the Drawings, and as required for a complete and operable system.
- B. The mechanical equipment shall be provided complete with all accessories, special tools, spare parts, mountings, and other appurtenances as specified, and as may be required for a complete and operating installation.
- C. It is the intent of these Specifications that the Contractor shall provide the Owner complete and operational equipment/systems. To this end, it is the responsibility of the Contractor to coordinate all interfaces with related mechanical, structural, electrical, instrumentation and control work and to provide necessary ancillary items such as controls, wiring, etc., to make each piece of equipment operational as intended by the Specifications.
- D. The complete installation shall be free from excessive vibration, cavitation, noise, and oil or water leaks.
- E. The requirements of this section shall apply to equipment furnished under Divisions 40, 41, 43 and 46.

**1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

- A. All equipment, materials, and installations shall conform to the requirements of the most recent editions with latest revisions, supplements, and amendments of the specifications, codes, and standards listed in Section 01 42 00 – References.

**1.03 SHOP DRAWINGS**

- A. Shop Drawings shall be submitted to the Engineer for all equipment in accordance with Section 01 33 00 – Submittal Procedures and shall include the following information in addition to the requirements of Section 01 33 00 – Submittal Procedures:
  - 1. Performance characteristics and descriptive data.
  - 2. Detailed equipment dimensional drawings and setting plans.
  - 3. General lifting, erection, installation, and adjustment instructions, and recommendations.

4. Complete information regarding location, type, size, and length of all field welds in accordance with American Welding Society Standards. Welding shall be performed by qualified and certified welders only.
5. The total uncrated weight of the equipment plus the approximate weight of shipped materials. Support locations and loads that will be transmitted to bases and foundations. Exact size, placement, and embedment requirements of all anchor bolts.
6. Details on materials of construction of all components including applicable ASTM designations.
7. Information on bearing types and bearing life.
8. Gear box design and performance criteria and AGMA service factor.
9. Piping schematics.
10. Motor data sheet indicating motor horsepower; enclosure type; voltage; insulation class; temperature rise and results of dielectric tests; service-rating; rotative speed; motor speed-torque relationship; efficiency and power factor at  $\frac{1}{2}$ ,  $\frac{3}{4}$ , and full load; slip at full load; running, full load, and locked rotor current values; and safe running time-current curves.
11. Equipment and motor protective device details. Connection diagrams for motor and all protective devices.
12. Equipment shop coating systems, interior and exterior.
13. Panel layout drawings, schematic wiring diagrams, and component product data sheets for control panels.
14. A list of spare parts and special tools to be provided.
15. Any additional information required to show conformance with the equipment specifications.
16. Warranty documentation including statement of duration of warranty period and contact phone numbers and addresses for warranty issues.

#### **1.04 OPERATION AND MAINTENANCE INSTRUCTION/MANUALS**

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
- B. O&M manuals shall include instructions, equipment ratings, technical bulletins, and any other printed matter such as wiring diagrams and schematics, prints or drawings, containing full information required for the proper operation, maintenance, and repair of

the equipment. Included in this submission shall be a spare parts diagram, complete spare parts list, bill of materials, OEM part numbers and manufacturer's catalog information of all equipment components.

- C. Each set of instructions shall be bound together in appropriate three-ring binders with a detailed Table of Contents.
- D. Written operation and maintenance instructions shall be required for all equipment items supplied for this project. The amount of detail shall be commensurate with the complexity of the equipment item.
- E. Information not applicable to the specific piece of equipment installed on this project shall be struck from the submission.
- F. Information provided shall include a source of replacement parts and names of service representatives, including address and telephone number.
- G. Extensive pictorial cuts of equipment are required for operator reference in servicing.
- H. When written instructions include Shop Drawings and other information previously reviewed by the Engineer, only those editions thereof which were approved by the Engineer, and which accurately depict the equipment installed, shall be incorporated in the instructions.

#### **1.05 GENERAL INFORMATION AND DESCRIPTION**

- A. All parts of the equipment furnished shall, be designed and constructed for the maximum stresses occurring during fabrication, transportation, installation, testing, and all conditions of operation. All materials shall be new, and both workmanship and materials shall be entirely suitable for the service to which the units are to be subjected and shall conform to all applicable sections of these Specifications.
- B. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these Specifications.
- C. Equipment and appurtenances shall be designed in conformity with ASTM, ASME, AIEE, NEMA, and other generally accepted applicable standards.
- D. All bearings and moving parts shall be adequately protected by bushings or other approved means against wear, and provision shall be made for accessible lubrication by extending lubrication lines and fittings to approximately 30 inches above finished floor elevation.
- E. Details shall be designed for appearance as well as utility. Protruding members, joints, corners, gear covers, etc., shall be finished in appearance. All exposed welds on machinery shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.

- F. Machinery parts shall conform within allowable tolerances to the dimensions shown on the working drawings.
- G. All machinery and equipment shall be safeguarded in accordance with the safety codes of the USA and the State in which the project is located.
- H. All rotating shafts, couplings, or other moving pieces of equipment shall be provided with suitable protective guards of sheet metal or wire mesh, neatly and rigidly supported. Guards shall be removable as required to provide access for repairs.
- I. All equipment greater than 100 pounds shall have lifting lugs, eyebolts, etc., for ease of lifting, without damage or undue stress exerted on its components.
- J. All manufactured items provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products.

#### **1.06 EQUIPMENT WARRANTIES**

- A. Warranty requirements may be added to or modified in the individual equipment specifications.
- B. The equipment furnished under this Contract shall be guaranteed to be free from defects in workmanship, design and/or materials for a period of one (1) year unless otherwise specified in the individual equipment specifications. The period of such warranties shall start on the date the particular equipment is placed in use by the Owner with corresponding start-up certification provided by the manufacturer's technical representative as specified herein, provided that the equipment demonstrates satisfactory performance during the thirty day operational period after the equipment startup. If the equipment does not perform satisfactorily during the thirty day operational period, the start of the warranty period will be delayed until the equipment demonstrates proper operation. The Equipment Supplier shall repair or replace without charge to the Owner any part of equipment which is defective or showing undue wear within the guarantee period, or replace the equipment with new equipment if the mechanical performance is unsatisfactory; furnishing all parts, materials, labor, etc., necessary to return the equipment to its specified performance level.
- C. The Contractor shall provide an equipment warranty log book prepared specifically for this project and submit two (2) copies of the document to the Engineer prior to final payment. The equipment warranty log book shall include a summary listing of all equipment warranties provided, date received, and start date and end date of warranty period. A copy of each equipment warranty and equipment start-up certification shall also be provided in the document.
- D. The Equipment Supplier shall guarantee to the Owner that all equipment offered under these specifications, or that any process resulting from the use of such equipment in the manner stated is not the subject of patent litigation, and that he has not knowingly

offered equipment, the installation or use of which is likely to result in a patent controversy, in which the Owner as user is likely to be made the defendant.

1. Where patent infringements are likely to occur, each Equipment Supplier shall submit, as a part of his bid, license arrangements between himself, or the manufacturer of the equipment offered, and the patent owner or the controller of the patent, which will permit the use in the specified manner of such mechanical equipment as he may be bidding.
2. Each Equipment Supplier, by submitting his bid, agrees to hold and save the Owner and Engineer or its officers, agents, servants, and employees harmless from liability of any nature or kind, including cost and expenses for, or on account of, any patented or unpatented invention, process, article, or appliance manufactured or used in the performance of the work under this contract, including the use of the same by the Owner.

## **PART 2 – PRODUCTS**

### **2.01 ACCEPTABLE MANUFACTURERS**

- A. The materials covered by these Specifications are intended to be equipment of proven reliability, and as manufactured by reputable manufacturers having experience in the production of such equipment. The Contractor shall, upon request of the Engineer, furnish the names of not less than 5 successful installations of the manufacturer's equipment of the same size and model of that offered under this contract. The equipment furnished shall be designed, constructed, and installed in accordance with the industry accepted practices and shall operate satisfactorily when installed as shown on the Drawings and operated per manufacturer's recommendations.

### **2.02 ANCHORS AND SUPPORTS**

- A. The Contractor shall furnish, install, and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of the devices included in the equipment specified. Working Drawings for installation shall be furnished by the equipment manufacturer, and suitable templates shall be used by the Contractor when required in the detailed equipment Specifications.
- B. Anchor bolts and fasteners shall be furnished in accordance with Section 05 05 23 – Metal Fastening, and with the individual equipment Specifications. All anchor bolts shall be a minimum of 1/2-inch diameter. All anchor bolts, handrail bolts, washers, clips, clamps, and fasteners of any type shall be constructed of 316 stainless steel, unless otherwise specified the individual equipment Specifications.
- C. The Contractor shall provide all concrete pads or pedestals required for equipment furnished. All concrete equipment pads shall be a minimum of 6" high, unless otherwise shown on the Drawings and shall be doweled.

- D. Pipe sleeves or other means of adjusting anchor bolts shall be provided where indicated or required. Equipment shall be leveled by first using sitting nuts on the anchor bolts, and then filling the space between the equipment base and concrete pedestal with non-shrink grout, unless alternate methods are recommended by the manufacturer and are acceptable to the Engineer (such as shim leveling pumps, or chemical grout). Non-shrink grout shall be as specified in Section 03 60 00 – Grout.

### **2.03 STRUCTURAL STEEL**

- A. Structural steel used for fabricating equipment shall conform to the requirements of Section 05 12 00 – Structural Steel.
- B. All materials shall conform to applicable provisions of the AISC Specifications for the design and fabrication of structural steel, and to pertinent ASTM Standard Specifications.

### **2.04 DISSIMILAR METALS**

- A. All dissimilar metals shall be properly isolated to the satisfaction of the Engineer.

### **2.05 GALVANIZING**

- A. Where required by the equipment specifications, galvanizing shall be performed in accordance with Section 05 05 13 – Galvanizing.

### **2.06 STANDARDIZATION OF GREASE FITTINGS**

- A. The grease fittings on all mechanical equipment shall be such that they can be serviced with a single type of grease gun. Fittings shall be “Zerk” type.

### **2.07 ELECTRICAL REQUIREMENTS**

- A. All electrical equipment and appurtenances, including but not limited to motors, panels, conduit and wiring, etc., specified in the equipment specifications shall comply with the applicable requirements of the Division 26 specifications and the latest National Electric Code.
- B. Motors shall conform to the applicable requirements of Section 26 05 60 – Low-Voltage Electric Motors.
- C. In the individual equipment specifications, specified motor horsepower is intended to be the minimum size motor to be provided. If a larger motor is required to meet the specified operating conditions and performance requirements, the Contractor shall furnish the larger sized motor and shall upgrade the electrical service (conduit, wires, starters, etc.) at no additional cost to the Owner.



- D. Motor starters and controls shall be furnished and installed under Division 26 and Division 40 unless otherwise specified in the individual pump specifications.

## **2.08 ACCESSORIES, SPARE PARTS, AND SPECIAL TOOLS**

- A. Spare parts for equipment shall be furnished where indicated in the equipment Specifications or where recommended by the equipment manufacturer.
- B. Spare parts shall be identical and interchangeable with original parts.
- C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- D. Painting requirements for spare parts shall be identical to those for original, installed parts. Where no painting or protective coating is specified, suitable provisions shall be made to protect against corrosion.
- E. Spare parts shall be delivered at the same time as the equipment to which they pertain. Spare parts shall be stored separately in a locked area, maintained by the Contractor, and shall be turned over to the Owner in a group prior to substantial completion. All of these materials shall be properly packed, labeled, and stored where directed by the Owner and Engineer.
- F. The Contractor shall furnish all special tools necessary to operate, disassemble, service, repair, and adjust the equipment in accordance with the manufacturers' operation and maintenance manual.
- G. The Contractor shall furnish a one-year supply of all recommended lubricating oils and greases. The manufacturer shall submit a list of at least four manufacturer's standard lubricants which may be used interchangeably for each type of lubricant required. All of these materials shall be properly packed, labeled and stored where directed by the Engineer.

## **2.09 EQUIPMENT IDENTIFICATION**

- A. All mechanical equipment shall be provided with a substantial stainless steel nameplate, mechanically fastened with stainless steel hardware in a conspicuous place, and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data.
- B. Each pump and other piece of mechanical equipment shall also be identified as to name and number by a suitable laminated plastic or stainless steel nameplate mechanically fastened with stainless steel hardware; for example, "Raw Water Pump #1". Coordinate name and number with same on remotely located controls, control panel, and other related equipment.

- C. Nameplates shall not be painted over.

## **PART 3 – EXECUTION**

### **3.01 SHOP TESTING**

- A. All equipment shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and that it will operate in the manner specified or implied.
- B. No equipment shall be shipped to the project until the Engineer has been furnished a certified copy of test results and has notified the Contractor, in writing, that the results of such tests are acceptable.
- C. An electronic copy of the manufacturer's actual test data and interpreted results thereof certified by the manufacturer shall be forwarded to the Engineer for review.
- D. If required by the individual equipment Specifications, arrangements shall be made for the Owner/Engineer to witness performance tests in the manufacturer's shop. The Engineer shall be notified ten working days before shop testing commences. Expenses are to be paid by Owner.
- E. Shop testing of electric motors shall be in accordance with applicable requirements of Section 26 05 60 – Low-Voltage Electric Motors, and Section 26 05 00 – Basic Electrical Requirements.

### **3.02 STORAGE OF EQUIPMENT AND MATERIALS**

- A. Contractor shall store his equipment and materials at the job site in strict accordance with the manufacturer's recommendations and as directed by the Owner or Engineer, and in conformity to applicable statutes, ordinances, regulations, and rulings of the public authority having jurisdiction. Equipment and materials shall not be delivered to the site prior to 90 days in advance of the scheduled installation. Partial payment requests will not be processed for materials delivered prior to 90 days before installation or for materials that are not properly stored.
- B. Material or equipment stored on the job site is stored at the Contractor's risk. Any damage sustained of whatever nature shall be repaired to the Engineer's satisfaction at no expense to the Owner. Stored electrical equipment is to be protected from the elements and shall have space heaters energized.
- C. Contractor shall not store unnecessary materials or equipment on the job site and shall take care to prevent any structure from being loaded with a weight which will endanger its security or the safety of persons.

- D. Contractor shall observe all regulatory signs for loadings on structures, fire safety, and smoking areas.
- E. Contractor shall not store materials or encroach upon private property without the written consent of the owners of such private property.

### **3.03 MANUFACTURER'S FIELD SERVICES**

- A. The Contractor shall arrange for a qualified Technical Representative from each manufacturer or supplier of equipment who is regularly involved in the inspection, installation, start-up, troubleshooting, testing, maintenance, and operation of the specified equipment. Qualification of the Technical Representative shall be appropriate to the type of equipment furnished and subject to the approval of the Engineer and the Owner. Where equipment furnished has significant process complexity, furnish the services of engineering personnel knowledgeable in the process involved and the function of the equipment. When necessary, the Contractor shall schedule multiple Technical Representatives to be present at the same time for the purpose of coordinating the operation of multiple pieces of related equipment.
- B. For each site visit, the Technical Representative shall submit jointly to the Owner, the Engineer, and the Contractor a complete signed report of the results of his inspection, operation, adjustments, and testing. The report shall include detailed descriptions of the points inspected, tests and adjustments made, quantitative results obtained if such are specified.
- C. The manufacturer's Technical Representative shall provide the following services.
  - 1. Installation: The Technical Representative shall inspect the installed equipment to verify that installation is in accordance with the manufacturer's requirements. Where required by individual equipment specifications, the Technical Representative shall also supervise the installation of the equipment.
  - 2. Testing: After installation of the equipment has been completed and the equipment is presumably ready for operation, but before it is operated by others, the Technical Representative shall inspect, operate, test, and adjust the equipment as required to prove that the equipment is in proper condition for satisfactory operation under the conditions specified. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for startup and that nothing in the installation will render the manufacturer's warranty null and void. The report shall include date of final acceptance field test, as well as a listing of all persons present during tests.
  - 3. Startup: The Technical Representative shall start up the equipment for actual service with the help of the Contractor. In the event that equipment or installation problems are experienced, the Contractor and the representative shall provide the necessary services until the equipment is operating satisfactorily and performing

according to the specifications at no additional cost to the Owner. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for permanent operation and that nothing in the installation will render the manufacturer's warranty null and void.

4. Training: The Technical Representative shall instruct the Owner's operating personnel in correct operation and maintenance procedures. The instruction shall demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment. Such instruction shall be scheduled at a time arranged with the Owner at least 2 weeks in advance of the training and shall be provided while the respective Technical Representative's equipment is fully operational. The Contractor shall have submitted, and had accepted, the O&M Manuals prior to commencement of training. Training shall be provided to the Owner's personnel between the hours of 8:00 A.M. and 6:00 P.M. as necessary.
  5. Services after Startup: Where required by the individual equipment specifications, the Technical Representative shall return to the project site thirty (30) days after the start up date to review the equipment performance, correct any equipment problems, and conduct operation and maintenance classes as required by the Owner. This follow-up trip is required in addition to the specified services of Technical Representative prior to and during equipment startup. At this time, if there are no equipment problems, each manufacturer shall certify to the Owner in writing that his equipment is fully operational and capable of meeting operating requirements. If the equipment is operating incorrectly, the Technical Representative will make no certification to the Owner until the problems are corrected and the equipment demonstrates a successful thirty (30) days operating period.
- D. Services of the Technical Representative will require a minimum of two (2) site visits, one for installation and testing and one for startup and training, and will be for the minimum number of days recommended by the manufacturer and approved by the Engineer but will not be less than the number of days specified in individual equipment sections.
- E. The Contract amount shall include the cost of furnishing the Technical Representative for the minimum number of days specified, and any additional time required to achieve successful installation and operation. The times specified for services by the Technical Representative in the equipment Specifications are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.
- F. The Contractor shall notify the Engineer at least 14 days in advance of each equipment test or Owner training session.

- G. The Technical Representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.

### **3.04 INSTALLATION**

- A. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation. Equipment shall be installed strictly in accordance with recommendations of the manufacturer. A copy of all installation instructions shall be furnished the Engineer's field representative one week prior to installation.
- B. The Contractor shall have on hand sufficient personnel, proper construction equipment, and machinery of ample capacity to facilitate the work and to handle all emergencies normally encountered in work of this character. To minimize field erection problems, mechanical units shall be factory-assembled insofar as practical.
- C. Equipment shall be erected in a neat and workmanlike manner on the foundations at the locations and elevations shown on the Drawings.
- D. All equipment sections and loose items shall be match-marked prior to shipping.
- E. For equipment such as pumping units, which require field alignment and connections, the Contractor shall provide the services of the manufacturer's qualified mechanic, millwright, or machinist, to align the pump and motor prior to making piping connections or anchoring the pump base. Alignment shall be as specified herein.
- F. The Contractor shall furnish oil and grease for initial operation and testing. The manufacturer and grades of oil and grease shall be in accordance with the recommendations of the equipment manufacturer.

### **3.05 ALIGNMENT**

- A. Set equipment to dimensions shown on drawings. Dimensions shall be accurate to +/- 1/16 inch unless otherwise noted on the drawings. Wedges shall not be used for leveling, aligning, or supporting equipment.
- B. General Equipment Leveling: Non-rotating equipment shall be set level to +/- 1/16 inch per 10-foot length (.005 inch per foot) unless otherwise noted on the drawings. Shims shall be used unless equipment is furnished with leveling feet. Set shims flush with equipment baseplate edges. When grouting is required, equipment shall be shimmed to allow a minimum of one inch grout thickness. Grout shall cover shims at least 3 inches. Final level check shall be held for inspection and approval by Engineer before proceeding.
- C. Grouting
  - 1. Fill anchor bolt holes or sleeves with grout, after bolt alignment is proven, and prior to placing grout under equipment bases.

2. Surface Preparation. Roughen surface by chipping, removing laitance, and unsound concrete. Clean area of all foreign material such as oil, grease, and scale. Saturate area with water at least 4 hours prior to grouting, removing excess water ponds.
  3. Application. Place grout after the equipment base has been set and its alignment and level have been approved. Form around the base, mix grout, and place in accordance with the grout manufacturers published instructions. Eliminate all air or water pockets beneath the base using a drag chain or rope.
  4. Finishing. Point the edges of the grout to form a smooth 45 degree slope.
  5. After grout has cured (not before 3 days after placement) paint exposed surfaces of grout with shellac.
  6. Level Verification. After grout has cured, and immediately prior to drive alignment, recheck equipment for level and plumb. Re-level and square as necessary. Hold final checks for inspection and approval by Engineer.
- D. Inspect for and remove all machining burrs or thread pulls in female holes on mating surfaces of mounting frame and machine feet.
- E. Inspect and clean equipment mounting base pads, feet, and frames to remove all grease, rust, paint and dirt.
- F. Assembled equipment shafts shall be set level to .0015 inches per foot of shaft length (+/- .0005 inches) up to a maximum of 0.015 inches for any length shaft unless the manufacturers requirements are more stringent or unless otherwise noted in the equipment specifications. Use the machined surfaces on which the equipment sets for the base/mounting frame leveling plane. Use the machined shaft surface for equipment leveling plane.
- G. Sprocket and Sheave Alignment. Check shaft mounted components for face runout and eccentricity (outside diameter) runout by magnetically mounting a dial indicator on a stationary base and indicating over 360 degrees on a continuous machined surface at the outside diameter of the component. Maximum allowable total indicated face runout and eccentricity for sprockets and sheaves will be per ANSI Standard B29.1-1975.
- H. Belt tensioning. Set drive belt tension to manufacturer's specification for the belt type. Recheck alignment after drive tensioning.
- I. Thermal/Mechanical Growth. Thermal/mechanical growth corrections for driver and driven machines will be used in vertical and horizontal alignment where applicable. The equipment manufacturer will determine thermal/mechanical growth applicability for any machine and provide the correction offsets to be used.
- J. Rotating Shaft Alignment

1. Fixtures will be set up on the driver and driven machine, machines shaft surfaces. Machined coupling hubs may be used only if there is no clearance to mount fixtures directly on the shafts.
2. Primary alignment method for direct drive machines is when coupled. Uncoupled alignment will be used only when approved by the Engineer.
3. Account for possible coupling flex by always rotating coupled machines in the same direction during alignment.
4. Uncoupled machines must be connected so that both shafts turn together without relative motion during alignment.
5. Indicator bar sag will be measured and included for each reverse indicator alignment setup.
6. Reverse Dial Indicator. The final maximum allowable misalignment: vertical and horizontal from the desired targets of .000 inches (for a non-thermal growth machine) or from the given target readings (for a thermal growth machine) must meet BOTH of the following conditions simultaneously: 1/2 the final total indicator reading at each indicator will be no more than shown in the table below AND the final remaining correction at each machine foot be no more than .001 inches of required movement.

Machine Speed (RPM)	Total Misalignment* (inches)
Up to 1800	.002
1800 and greater	.001

\* 1/2 indicator reading

### 3.06 FIELD TESTING

- A. All equipment shall be set, aligned and assembled in conformance with the manufacturer's drawings and instructions. Provide all necessary calibrated instruments to execute performance tests. Submit report certified by the pump manufacturer's representative.
- B. Preliminary Field Tests, Yellow Tag
  1. As soon as conditions permit, after the equipment has been secured in its permanent position, the Contractor shall:
    - a. Verify that the equipment is free from defects.
    - b. Check for alignment as specified herein.

- c. Check for direction of rotation.
- d. Check motor for no load current draw.
2. Contractor shall flush all bearings, gear housings, etc., in accordance with the manufacturer's recommendations, to remove any foreign matter accumulated during shipment, storage or erection. Lubricants shall be added as required by the manufacturer's instructions.
3. When the Contractor has demonstrated to the Engineer that the equipment is ready for operation, a yellow tag will be issued. The tag will be signed by the Engineer, or his assigned representative and attached to the equipment. The tag shall not be removed.
4. Preliminary field tests, yellow tag, must be completed before equipment is subjected to final field tests, blue tag.

C. Final Field Tests, Blue Tag

1. Upon completion of the above, and at a time approved by the Engineer, the equipment will be tested by operating it as a unit with all related piping, ducting, electrical and controls, and other ancillary facilities.
2. The equipment will be placed in continuous operation as prescribed or required and witnessed by the Engineer or his assigned representative and the Owner or his assigned representative.
3. The tests shall prove that the equipment and appurtenances are properly installed, meet their operating cycles and are free from defects such as overheating, overloading, and undue vibration and noise. Operating field tests shall consist of the following:
  - a. Check equipment for excessive vibration and noise as specified herein.
  - b. Check motor current draw under load conditions. The rated motor nameplate current shall not be exceeded.
  - c. Recheck alignment with dial indicators where applicable, after unit has run under load for a minimum of 24 hours.

D. In addition to the above described field tests, any other tests specifically required by Section 43 20 00 – Pumps-General, the individual equipment Specifications, or by the manufacturer shall be performed.

E. Until final field tests are acceptable to the Engineer, the Contractor shall make all necessary changes, readjustments and replacements at no additional cost to the Owner.



- F. Upon acceptance of the field tests, a blue tag will be issued. The tag will be signed by the Engineer and attached to the unit. The tag shall not be removed and no further construction work will be performed on the unit, except as required during start-up operations and directed by the Engineer.
- G. Defects which cannot be corrected by installation adjustments will be sufficient grounds for rejection of any equipment.
- H. All costs in connection with field testing of equipment such as lubricants, temporary instruments, labor, equipment, etc., shall be borne by the Contractor. Power, fuel, chemicals, water, etc. normally consumed by specific equipment shall be supplied by the Owner unless otherwise specified in the individual equipment specifications.
- I. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.
- J. Field testing of electric motors shall be in accordance with Section 26 05 60 – Low-Voltage Electric Motors, and Section 26 05 00, Basic Electrical Requirements.

### **3.07 VIBRATION TESTING**

- A. Unless specified otherwise in the detailed equipment specifications, each pump, blower, compressor, motor or similar item of stationary rotating equipment having a rated power in excess of 40HP shall be tested after installation for acceptable vibration levels.
- B. Vibration testing shall be performed by an experienced factory-trained and authorized third-party analysis expert (not a sales representative) retained by the Contractor and approved by the Engineer. Each unit or pump system shall be tested separately without duplicate equipment running. All field testing shall be done in the presence of the Engineer. The Engineer shall be furnished with four (4) certified copies of vibration test data for each test performed.
- C. For systems with variable speed drives, tests shall be conducted at various speeds between maximum and minimum. For systems with two-speed drives, tests shall be conducted at both speeds. For systems with constant-speed drive, tests shall be conducted under various loading conditions as determined by the Engineer.
- D. All field vibration tests shall be performed with the equipment operating on the product for which it is intended, or a substitute acceptable to the Engineer.
- E. The term displacement, as used herein, shall mean total peak-to-peak movement of vibrating equipment, in mils; velocity or speed of the vibration cycle, measured in G's. Displacement and velocity shall be measured by suitable equipment equal to IRD Mechanalysis, Bentley, Nevada.

- F. Frequency of vibration, in cycles per minute (cpm), shall be determined when vibration exceeds specified levels or as otherwise necessary. Vibration shall be measured on the bearing housing, unless other locations are deemed necessary by the vibration analysis expert and Engineer.
- G. For all equipment tested, vibration shall be checked in the radial and axial directions. Unless otherwise specified elsewhere, axial vibration shall not exceed 0.1 in/sec; and radial vibration shall not exceed 0.2 in/sec. For pumps radial vibration shall not exceed that permitted by the Hydraulic Institute Standards except that, at vibration frequencies in excess of 8,000 cpm, the velocity shall not exceed 0.2 in/sec.
- H. Copies of test results shall be submitted to the Engineer for review. Should the vibration field test results exceed shop test results, the manufacturer's recommendations, or the limits specified herein, the Contractor shall correct the deficiencies within thirty (30) days. After corrections have been completed, the vibration testing shall be re-run and the results re-submitted to the Engineer for review.
- I. Noise or vibration in any rotating equipment which the Engineer judges to be excessive or damaging, shall be cause for rejection.

### **3.08 FAILURE OF EQUIPMENT TO PERFORM**

- A. Any defects in the equipment, or failure to meet the guarantees or performance requirements of the Specifications shall be promptly corrected by the Contractor by replacements or otherwise.
- B. If the Contractor fails to make these corrections, or if the improved equipment shall fail again to meet the guarantees or specified requirements, the Owner, notwithstanding his having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Contractor to remove it from the premises at the Contractor's expense.
- C. The Contractor shall then obtain specified equipment to meet the contract requirements or upon mutual agreement with the Owner, adjust the contract price to reflect not supplying the specific equipment item.
- D. In case the Owner rejects said equipment, then the Contractor hereby agrees to repay to the Owner all sums of money paid to him for said rejected equipment on progress certificates or otherwise on account of the lump sum prices herein specified.
- E. Upon receipt of said sums of money, the Owner will execute and deliver to the Contractor a bill of sale of all his rights, title, and interest in and to said rejected equipment; provided, however, that said equipment shall not be removed from the premises until the Owner obtains from other sources other equipment to take the place of that rejected.

- F. Said bill of sale shall not abrogate Owner's right to recover damages for delays, losses, or other conditions arising out of the basic contract.

### **3.09 PAINTING**

- A. All surface preparation, shop painting, field repairs, finish painting, and other pertinent detailed painting specifications shall conform to applicable sections of Section 09 90 00 – Painting.
- B. All shop coatings shall be compatible with proposed field coatings.
- C. All inaccessible surfaces of the equipment, which normally require painting, shall be finished painted by the manufacturer. The equipment and motor shall be painted with a high quality epoxy polyamide semi-gloss coating specifically resistant to chemical, solvent, moisture, and acid environmental conditions, unless otherwise specified.
- D. Gears, bearing surfaces, and other unpainted surfaces shall be protected prior to shipment by a heavy covering of rust-preventive compound sprayed or hand applied which shall be maintained until the equipment is placed in operation. This coating shall be easily removable by a solvent.

### **3.10 WELDING**

- A. The Equipment Manufacturer's shop welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirement of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.
- B. The Contractor's welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirements of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.
- C. The Contractor shall perform all field welding in conformance with the information shown on the Equipment Manufacturer's drawings regarding location, type, size, and length of all welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society, and special conditions, as shown by notes and details.

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**SECTION 46 21 13**  
**MULTI-RAKE BAR SCREENS AND SCREENINGS CONVEYORS**

**PART 1 – GENERAL**

**1.01 THE REQUIREMENT**

- A. The Contractor shall furnish, install, test, paint, and place in satisfactory operation, multi-rake bar screens (screens) and screenings conveyors as specified herein and as shown on the Drawings.
- B. The equipment shall be provided complete with all accessories, special tools, spare parts, mountings and other appurtenances as specified and as may be required for a complete and operating installation. Contractor shall supply anchor bolts.
- C. All vertical and horizontal alignments and interconnecting parts between the screens, screenings conveyors and all other ancillary equipment as described herein shall be coordinated by the Contractor with the Manufacturer to insure a complete and fully operational design. Any modifications or changes to the structure necessary to facilitate the installation of the screening equipment shall be the responsibility of the Contractor at no additional cost to the Owner.
- D. It shall be the Contractor's responsibility to ensure that the mechanically cleaned bar screen furnished and installed shall be compatible and have the necessary operating clearances with the structural elements and equipment shown on the Contract Drawings.
- E. Layout, dimensions, and elevations shown on the Drawings are representative of the mechanical bar screen. Any costs for re-design, materials, or construction due to requirements of the mechanical bar screen equipment ultimately furnished shall be the responsibility of the Contractor.
- F. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.
- G. Motor starters, remote interlocking control and alarm circuits, power wiring, conduit, and power and control connections, exterior to the equipment, shall be furnished in accordance with Division 26 – Electrical, unless otherwise specified hereinafter.

**1.02 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS**

- A. The mechanical bar screen shall be designed for operation in a rectangular channel for removal of screenings from flowing raw sewage and discharging the screenings to the screenings conveyor.
- B. Screenings shall be mechanically raised on the screen to the dead plate and automatically discharged as specified in this section.

- C. The screen frame shall be set in the channel and designed for installation with sidewall seal plates, furnished with the screen, so the screen can be removed for servicing. The screen shall be front cleaning with multiple rakes entering the bar rack from the upstream side of the rack. Back cleaned screens and single rake designs shall not be acceptable.
- D. Screen shall be heavy-duty, vertical, front cleaned, front return type with traveling cleaning rakes transported on a chain and sprocket mechanism.
- E. The screen shall be designed to operate outdoors in a damp, wet, corrosive atmosphere.
- F. All parts of the equipment furnished herein shall be amply proportioned for all stresses that may occur during fabrication, shipment, erection, and continuous operation.
- G. All corresponding parts shall be interchangeable, and all parts subject to wear shall be standard pattern and easily replaceable.
- H. Adequate lubrication shall be provided for bearings, and lubrication points shall be readily accessible or piped to an accessible point with appropriate label.
- I. All electrical components, switches, conduits, etc. shall be rated for use in a Class I, Division 2, Group D, hazardous location. All screen and conveyor mounted electrical devices with "make and break" contacts shall be mounted in NEMA 7 enclosures.
- J. Equipment Schedule - Multi-Rake Bar Screens

<b>Equipment Characteristics</b>	
Number of Units	1
Tag Numbers	SCR-1
Clear Opening Between Bars	1/2"
Bar Width	0.31" (Tapered or Teardrop)
Angle of Inclination (from horizontal)	75°
Screen Speed per Cleaning Interval	10 sec (normal operation) 5 sec (high speed)
Motor Horsepower (maximum)	3 hp
<b>Flow Conditions</b>	
Minimum Flow/Unit, (MGD)	0.2
Design Flow/Unit, (MGD)	0.4
Peak Flow/Unit, (MGD)	1.4
<b>Performance Requirements</b>	
Upstream Channel width	See Drawings
Downstream Channel width	See Drawings
Channel depth (Interior)	15'-0"
Channel invert at screen, elevation	879.00
Operating floor elevation (top of slab)	894.00
Max Head-loss allowable at peak flow, clean screen	8"
Max Head-loss allowable at peak flow, 50% Blind	2'-10"
Downstream Water Depth (from Channel Invert) at Max Flow	11"

K. Equipment Schedule – Screenings Conveyors

<b>Equipment Characteristics</b>	
Number of Units	1
Tag Numbers	SCC-1
Minimum screw diameter	12"
Maximum screw length	As Required
Minimum drain connection	3"
Inclination / Slope	25°
Pressure Relief Cover(s)	Yes
Conveyor Style	Shafted or Shaftless
<b>Flow Conditions</b>	
Minimum Flow/Unit, (MGD)	0.2
Design Flow/Unit, (MGD)	1.5
Peak Flow/Unit, (MGD)	5.6
<b>Performance Requirements</b>	
Minimum Capacity, each	20 cf/hr
Feed concentration, % dry solids	1-2.5%
Screenings discharge, % dry solids	35%

**1.03 SUBMITTALS**

A. The following items shall be submitted with the Shop Drawings in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions:

1. Performance Affidavit
2. Horsepower
3. Voltage
4. Rotative Speed of Motors
5. Total Weight of Equipment
6. Approximate Weight of Shipped Materials
7. Complete Erection, Installation, and Adjustment Instructions and Recommendations
8. Electrical Schematic Wiring Diagrams Indicating all Controls and Interlocks for Proper Operation of Equipment
9. Operations and Maintenance Manuals

## **PART 2 – EQUIPMENT**

### **2.01 ACCEPTABLE MANUFACTURERS**

- A. Acceptable manufacturers of the screens and screenings conveyors shall be Huber Technology, JWC, Headworks, Duperon or approved equal.

### **2.02 MULTI-RAKE BAR SCREEN**

- A. The bar screen shall include cleaning rakes, rake wiper, chains, sprockets, shafts, bearings, drive unit complete with reducer, motor and overload device, side frames with lifting lugs, bar rack, dead plate, discharge chute, head section, side wall sealing plates, and mounting brackets. Plastic filter elements shall not be acceptable.
- B. The cleaning rakes shall be activated to remove screenings deposited on the bar rack both by level control and by timer actuation. When the rakes reach the bottom position of the rotational path, the rake tines shall be engaged into the bars. The rake shall then be raised, transporting the screenings upwards towards the discharge position.
- C. An overcurrent protection relay or torque overload switch shall be provided to detect a rapid increase in motor current due to excessive loads or equipment binding. Positive overload protection against an object which is too large to be discharged shall be provided by a shear bolt. Further requirements are listed under Electrical Requirements (paragraph 2.04) and Controls and Instrumentation (paragraph 2.05).
- D. The rake shall be traversed forward over the discharge chute apex by action of the L-shaped guides mounted in the side frame. The wiper shall be designed to pivot to allow efficient cleaning of the rake on each pass and cushioned during travel to the rest position by a compression spring or the rake as it turns to go down.

**E. Unless specified otherwise hereinafter, stainless steel shall be ASTM A-167, Type 316L.**

#### **F. Frame**

1. The bar rack and dead plate shall be supported by heavy rigid structural steel side frames, resulting in a structurally self-supporting unit. The screen shall not be attached directly to the walls or channel floor and shall be designed to be pulled out of the channel.
2. The side frames shall be adequately designed for the intended duty and constructed of at least 3/16-inch 316L stainless steel plate formed to a channel section and suitably reinforced to support the required loads. Support beams shall be provided on the front of the frame above the maximum waterline. Beams shall be 3/16-inch thick, U-shape.
3. The side frames shall include L-shaped guides for both the carrying and return run of the screen chain. The L-shaped guides shall assure proper meshing between



the rake teeth and the dead plate and shall be securely fixed to the side frames for the full height of travel. The L-shaped guides shall be of 316L stainless steel, of 2.5-inch minimum width.

4. The side frames shall include shrouds around the footshaft sprockets to prevent debris from interfering with the proper meshing of the chains and sprockets. The shrouds shall also be designed to prevent grit accumulation at the chain and sprocket location. Shrouds are not needed if the chain and sprockets are completely outside of the channel flow or if sprockets are not utilized in the design of the screen.
5. Mounting brackets shall be furnished on the back side of the screen that is fixed to the channel walls. The brackets shall not be less than ¼-inch x 3-inch x 3-inch, 316L stainless steel anchored to the wall by no less than three (3) stud anchors.
6. Rubber channel wall seals shall be furnished on the front side of the screen to seal the spacing between the screen frame and the channel wall. Seals shall be fastened to the screen via a 316L stainless steel flat bar bolted to the frame. The seal shall span the entire height of the frame from the channel floor to the top of the bar rack.
7. Side frames shall be secured to the top of the channel walls by use of a flanged section sized by the manufacturer and field mounted by the contractor. The flanged section shall include mounting holes for anchors into the concrete and the top of the flange shall be field welded to the side frame.
8. Lifting lugs shall be provided on the side frames and shall be of sufficient quantity and position to aid removal of the screen from the channel.
9. Maintenance access to the chain rollers, pins, side rails, rake head connections shall be through easily removable, ¼-inch thick stainless-steel covers in the side frame above the top of the channel.

#### G. Bar Rack

1. The bar rack shall consist of 316L stainless steel, vertical, continuous tapered or teardrop, section bars and held firmly and accurately in place by means of bolted fingerplates incorporating Type 316L stainless steel hardware. Horizontal supports shall be used to reinforce the screen-field bars, such that the bar screen supports the loads of partially or fully blinded conditions. Fully blinded conditions are assumed to be the full depth of the channel, as described in the Equipment Schedule.
2. The screen field shall be accurately constructed to give a clear opening between the bars, per the equipment schedule. There shall be no spaces wider than the opening between the bars which would permit passage of larger solids through the screen.

3. The bar rack shall extend from the bottom of the channel to a height of three (3) feet above the channel bottom and shall be fastened at that point to a dead plate.
4. Bars, bar rack, and dead plate shall be supported from the framework. Bars shall be readily removable. The bar rack shall be constructed so that screen bars are replaceable in cassettes or individually replaceable without welding or cutting. Bars that are supported from the framework and removable in sections shall be acceptable.

#### H. Cleaning Rakes

1. The screening rakes shall be designed such that screenings will not wrap around the tines or the stationary bars and will not fall back into the sewage flow during the cleaning cycle.
2. The cleaning rakes shall be mounted on two (2) strands of chain running over two (2) sets of sprocket wheels. Rakes shall run in guides on both sides to ensure engagement and clean bars from the upstream side of the screen. The debris shall be removed from the bar racks by the cleaning rakes, conveyed up the dead plate to the discharge point where the rakes shall be cleaned by the rake wiper.
3. Cleaning rakes shall be 316L stainless steel with teeth of suitable thickness and depth to effectively clean the front and sides of the bars. Rake bar thickness shall be 1/2-inch with a reinforcement profile of 1/4-inch and side sheets of at least 3/8-inch thickness. Alternatively, each rake head assembly shall consist of a rake tooth plate and rake shelf. Rake head shall be precision cut from 3/4-inch thick plate having a minimum depth of 8-inches. The rake head teeth shall be shaped to properly engage the clear space openings in the bar rack. The rake teeth shall engage into the bar rack a minimum of 50 percent of the bar depth. The rake tooth plate shall be replaceable and shall attach to a formed rake shelf. The formed rake shelf and integral end plates shall be manufactured from 1/4-inch thick plate. Each rake head shall have a minimum carrying capacity of 0.22 cu ft/ft of rake head width.
4. The raking tines shall have the tooth profile precision cut from a single continuous bar of sufficient thickness and depth to ensure adequate stiffness and strength to sufficiently handle the duty cycles.
5. The rake tines shall penetrate into the screen bar spacing to ensure that screenings are completely cleared during each lifting operation. Rake tines are mechanically engaged into the screen bars. During each cleaning stroke, the raking tines shall engage into the bottom of the bar screen grids at the channel invert. Drive chains, chain guides, chain sprockets, bearings, and axles shall be fully replaceable without having to remove the screen from the channel.

#### I. Discharge System

1. Screenings transported to the top of the screen shall be discharged by means of a mechanical scraper.
2. The rake wiper, of not less than 3/16" thick 316L stainless steel, shall be furnished with replaceable 3/8" thick polyethylene wiper blade and wear strips bolted to two (2) structural pivot arms. The arms shall be mounted on a minimum one (1) inch diameter pivot shaft and supported by self-aligning ball bearings. The wiper arms shall be designed to return the wiper quietly and without shock to the screen. The entire wiper mechanism shall be located within the head section.
3. The scraper mechanism shall be fitted with a compression spring or shock absorber that allows the scraper to return to its resting position smoothly without any shock.

#### J. Discharge Hoppers

1. Each mechanical bar screen shall be provided with a discharge hopper. Discharge hoppers shall be fabricated from 5/32-inch Type 304L stainless steel.
  - a. Each hopper shall be designed independently according to the receiving equipment below the specific screen.
  - b. Hoppers shall be designed to taper at an angle no less than 60 degrees from horizontal to provide a transition from the width of the mechanical screen discharge to the width of the receiving equipment below the screen.
  - c. Each hopper shall be provided with a vertical extension chute of sufficient length to direct screenings from the hopper to the inlet of the conveyor as indicated on the Drawings. Extension chutes shall be fabricated from 14-gauge Type 304L stainless steel and shall be provided with a 12" square hinged inspection hatch.
  - d. Each hopper shall be provided with a screenings diverter bypass chute mounted in the back of the discharge hopper that will swing out to provide a bypass of the screenings out over the screen conveyor. The bypass chute shall be recessed in the back of the hopper to prevent any buildup of screenings material when in the retracted position. The access door shall be designed in such a manner to allow the bypass chute to swing out and locked in place to allow the screening to discharge on the floor. This switch shall be easily done by an operator without any tools.
2. A 1/8-inch thick 60 Durometer Neoprene rubber gasket shall be provided to seal the extension chute to the inlet flange connection of the associated equipment item.
3. Hopper design submittals shall be coordinated with all associated equipment items to ensure proper fit of overall screenings discharge system (including all vertical

and horizontal dimensions of the hoppers, chutes, mechanical screens, and associated equipment items such as conveyors and screenings presses).

K. Dead Plate

1. The dead plate and apron shall be constructed of not less than 3/16-inch thick 316L stainless steel plate, shop welded to the side frames of the screen.
2. The dead plate shall extend from the bar rack to the top of the discharge apron. Appropriate support/stiffening of the dead plate shall be provided on its back side to guarantee a maximum gap between the rack bar and dead plate, leading to the discharge chute without interruption.

L. Sprockets

1. Sprockets for the screen chains shall be Type 316L stainless steel. The screen chain sprockets shall not be less than 8-tooth, 12.5 PD. Footshaft sprockets shall be free to turn on the stub shaft and held in place by use of a retainer plate bolted to the shaft. Footshaft sprockets and stub shaft shall be provided with UHMWPE, stooody, or silicium carbide slide, bushings. The lower sprocket shall be of proven self-lubricating material and be maintenance free. No lower bearing requiring lubrication shall be allowed.

M. Chains

1. The screen chains shall be 316L stainless steel of high tensile strength and corrosion resistant. The chain pitch shall be approximately 6-inch. The chain pins shall be stainless steel and hardened. The assembled chain shall have an ultimate strength not less than 24,000 lbs.
2. Chain guide shall be securely fixed to the screen frame for the full height of travel and shall not protrude into the flow.

N. Head Section

1. The side frames of the bar screen shall act as the side panels of the head section above the operating floor. The head section shall be fabricated of not less than 3/16-inch thick 316L stainless steel plate. The hood over the headshaft assembly shall be removable and provided with lifting handles for access to the headshaft. The head section shall be provided with stainless steel inspection doors located for easy access.

O. Shafting

1. All shafting shall be 316L stainless steel. Keyways with fitted keys shall be provided where necessary.

2. The headshaft shall drive both chain assemblies and be equipped with an adjustable screw type take-up providing for a 6-inch adjustment of the screen chains.
3. The footshaft shall be fixed replaceable steel stub shaft with a bonded ceramic collar or a stainless-steel stub shaft with a field replaceable hardened steel sleeve.

P. Anchor Bolts

1. All anchor bolts, bolts, and nuts shall be 316 stainless steel of ample size and strength for the purpose intended and as shown on the Drawings. Anchor bolts shall be a minimum of  $\frac{3}{4}$ -inch thick and shall be provided by the Contractor.

Q. Bearings

1. Bearings for the upper sprocket shall be the UCT take-up type, housed, and grease lubricated. Bearings shall be cast steel, cast iron-housed, adjusted by threading a stainless-steel screw up and down in two (2) milled guide slots.
2. Bearings for the lower sprocket shall be of polyethylene construction and self-lubricated, provided with a ceramic collar to fit around the stub shaft.
3. Alternatively, the upper sprockets shall be key mounted onto a drive shaft. The lower sprockets shall rotate on a 304 stainless steel stub shaft with a hardened steel sleeve attached to the frame. Lower sprocket bearings shall be manufactured from a self-lubricating, abrasion resistant polymeric synthetic material. Lower sprockets and bearings shall be replaceable without removing the screen from the channel.

R. Drive Unit

1. The drive unit shall be of the motorized type mounted on an adjustable drive chain take-up base on the screen head section. The drive unit speed reducer shall be of the helical gear type, fully housed, running in oil, with anti-friction bearings throughout and close coupled to the motor.
2. The drive unit shall be assembled by the Manufacturer and shipped as a complete assembly to ensure proper assembly of all components.
3. The motor shall be suitable for duty in a corrosive atmosphere and high shock loads complying with the applicable provisions of the standards of NEMA and IEEE. Motors shall conform to the applicable requirements of Section 26 05 60 – Low-Voltage Electric Motors.
4. The drive mechanism for the rakes shall incorporate a solid shaft constructed of stainless-steel Grade 316L. The drive unit, including the reduction gearbox, shall be directly shaft-mounted and shall be positioned to facilitate maintenance work.

## 2.03 SCREENINGS CONVEYORS

- A. Unless specified otherwise hereinafter, all materials shall be ASTM A-167, Type 304L stainless steel. All stainless steel shall be pickled and passivated in accordance with the requirements of ASTM A-380. At a minimum, all stainless-steel surfaces shall be bead blasted prior to assembly to removal all weld discoloration and surface contaminants and provide for Spontaneous Passivation as recognized in ASTM A380-99
- B. Troughs, Covers, End Plates And Chutes
  - 1. Conveyor Troughs
    - a. Conveyor trough bodies shall be "U" type with trough dimensions conforming to the requirements of CEMA Standard 300, with exceptions as noted herein. The conveyor trough bodies shall be rolled to shape with the double formed top flanges formed with, or welded to, the trough body. Trough end flanges, welded to each trough section, shall be provided for joining adjacent sections or connecting trough end plates to the trough sections.
    - b. Individual trough segment lengths, measured from end flange to end flange shall not exceed the lengths given in the conveyor schedule for each conveyor. Conveyors with lengths greater than the maximum individual trough segment length shall be constructed of two or more sections bolted together at the trough end joining flanges.
    - c. Each shafted screw conveyor trough shall be equipped with 3-inch diameter NPT drain nipples located at the drive and tail trough ends and at each intermediate bearing location. The drain nipple(s) shall extend three inches below the screw conveyor trough and be supplied with a threaded cap.
    - d. Each shaftless screw conveyor trough shall be equipped with 3-inch diameter NPT drain nipples located at the drive and tail trough ends. The drain nipple(s) shall extend three inches below the screw conveyor trough and be supplied with a threaded cap.
    - e. Conveyor troughs for shaftless screw conveyors shall be equipped with a wear liner across the entire inside length. The wear liner shall be fabricated of 1/2-inch thick (minimum) high density UHMW polyethylene with sintered wear resistant filler and synthetic lubricant. The wear liner shall be provided in 4-foot long sections (maximum length) for ease of replacement. The wear liner shall be held in place using stainless steel clips welded or bolted to the inside of the trough. Clips and bolts shall be placed away from the conveyor spiral path.
    - f. Conveyor troughs for shaftless screw conveyors shall be furnished with anti-floatation devices. The anti-floatation devices shall be fabricated of HDPE flat bars with a minimum thickness of 3/8-inch and a minimum width of 2-

inches. The anti-floatation device bar shall run the entire length of the screw conveyor and shall be located above the screw on both sides of the trough. The bars shall be supported by stainless steel brackets attached to the trough cover flange every two-feet.

## 2. Conveyor Covers

- a. A sectional stainless steel plate shall cover the entire trough, with the exception of where the inlet chute connections are located. Cover segments at inlet chute connections shall extend, on each side, beyond the inlet chute connection and shall be bolted in place. Each cover section shall be not greater than 6-feet in length. The cover segments shall be arranged so that the trough flange and a trough stiffener provide support to each edge.
- b. The covers shall open for maintenance and cleaning purposes. The cover shall be furnished with a toggle-clamp type, or spring clip type, quick release connections on each side of the cover. The quick release connectors shall remain attached to the conveyor trough when the cover is removed.
- c. Gaskets shall be installed along each trough cover flange and each stiffener to ensure a drip proof connection and minimize air leakage through the conveyor cover.
- d. Pressure relief covers shall be provided at conveyor discharge ends when required by the conveyor schedule and shall expose the full width of the conveyor trough when opened. Pressure relief covers shall be designed to open upon build-up and packing of material at the discharge endpoint. Pressure relief covers shall be supplied with safety limit switches as described elsewhere in this section.

## 3. Conveyor End Plates

- a. End plates shall be fabricated from stainless steel plate and shall be bolted and gasketed to the trough end flange. End plates shall be designed to support the drives, bearings and gear reduction assembly.
- b. The end plate assembly shall be supported independently of the conveyor troughs. Support points for the drive and tail end assemblies shall be welded to the end plates.
- c. Where shafts penetrate the end plates the end plate shall be provided to accommodate the stuffing box.

## 4. Conveyor Chutes

- a. Trough inlet and discharge chutes shall be bolted to the adjoining equipment as shown on the Contract Drawings. Inlet and discharge chutes shall be supplied with reinforced rectangular or circular flanges.
- b. Trough inlet chute connection flanges shall be located approximately 3-inches above the top of the conveyor trough. Trough discharge chute connection flanges shall be located approximately 3-inches below the bottom of the conveyor trough.
- c. The Conveyor Equipment Supplier shall furnish connection chutes and transition pieces between the conveyors and related equipment. Chute connections and transition pieces with length greater than 2-feet between flanges shall include at least four handles to facilitate removal of the connection chute. Handles shall be fabricated from 1/2-inch diameter rod of the same material as the chute, formed and welded to the sides of the chute.
- d. Where shown on the drawings, conveyor equipment supplier shall furnish flexible discharge chutes fabricated from heavy duty rubber resistant to deterioration from contact with dewatered sludge or outdoor exposure.
- e. Full-face gaskets shall be provided between each flanged inlet, discharge, connection and transition chute.

#### C. Conveyor Drive Train Equipment

1. The conveyor drive train equipment shall transmit power to the conveyor drive shaft using a shaft mounted speed reducer directly connected to an electric motor.
2. Drive Shaft Assembly
  - a. The drive end assembly shall consist of the following components.
    - 1) Drive Shaft
    - 2) Packing Gland/Stuffing Box
    - 3) Hollow Shaft Gear Reducer
    - 4) Bearing and Housing
    - 5) Drive Motor
  - b. The tail end shaft assembly shall consist of the following components
    - 1) Tail Shaft
    - 2) Packing Gland/Stuffing Box



### 3) Bearing and Housing

- c. Only a drive end assembly shall be provided for shaftless screw conveyors. Both drive end and tail end assemblies shall be provided for shafted screw conveyors.
- d. Drive shafts and tail shafts on shafted screw conveyors are to be complete with mating connections appropriate for mating the drive shaft to the rotor center tube. Drive shafts for the shaftless screw conveyors are to be complete with mating connections appropriate for mating to the shaftless screw assembly. The drive and tail shafts shall be of adequate diameter to handle all radial, thrust and torsion loads. The drive and tail end shafts shall be mounted to the shafted rotor or shaftless spiral by a flanged connection.
- e. An adjustable packing gland seal shall be provided where shafts project through the conveyor end plate. Packing glands shall be provided with not less than five packing rings per stuffing box. Packing shall be grease lubricated. Grease fitting(s) shall be provided to lubricate the packing rings.
- f. The drive end shaft shall be provided with both an inside and outside support bearing. The bearings shall be spherical roller bearings mounted in pillow block bearing housings. The inner drive end bearing shall be “free floating” and designed to handle radial loadings. The outer drive end bearing shall be “fixed” and designed to handle radial and thrust loads. The outer drive end bearing shall be mounted outboard of the packing gland/stuffing box assembly with sufficient clearance to permit removal of stuffing box bolts, cover and repack the stuffing box without having to remove the bearing housing or bearing from the housing. The bearing housing shall be fitted with an Alemite grease fitting. Grease feed tubing shall be run from the inner support bearing to a location on the conveyor exterior to facilitate lubrication.
- g. The tail end shaft shall be provided with an outside support bearing. The bearing shall be a spherical roller bearing, mounted in a pillow block bearing housing. The outside support bearing shall be outboard of the packing gland/stuffing box assembly with sufficient clearance to permit removal of stuffing box bolts, cover and repack the stuffing box without having to remove the bearing housing or bearing from the housing. The bearing housing shall be fitted with an Alemite grease fitting.
- h. The support bearings shall conform to the standards of the Anti-Friction Bearing Manufacturer’s Association (AFBMA) and shall have a minimum L-10 life expectancy of 50,000 hours under the design loading condition.

### 3. Drive Motor

- a. Drive motors shall conform to the applicable requirements of Section 26 05 60 – Low-Voltage Electric Motors.

b. Drive motors shall be suitable for continuous severe duty service.

#### 4. Speed Reducer

- a. The speed reducer shall be a direct driven, enclosed shaft mount type unit. The speed reducer shall mount directly on the driven shaft. All gears shall be AGMA Class II, single or double reduction, helical gear units with high capacity roller bearings. The reducer will be the standard air-cooled unit with no auxiliary cooling.
- b. The speed reducer housing shall be constructed of ductile, iron and shall be ribbed for added strength.
- c. The speed reducer bearings shall be ball or tapered roller type and provide a 50,000-hour B-10 life at the expected design loading rate. All seals shall be double lip, spring-loaded type and made of nitrile rubber.
- d. Speed reducer gears and bearings shall be splash lubricated using petroleum-based oil, containing anti-foam and rust inhibiting additives. Speed reducer installation shall be accomplished by using ductile iron, fully split, twin tapered bushings keyed to the shaft. Reducer removal shall be accomplished by providing jack screw holes in the bushing flanges to mechanically remove the tapered assembly.
- e. The speed reducer shall be manufactured to Quality Class 8 per AGMA Standard 6001-C88, minimum. The gear reducer shall be selected for AGMA Class 11 service with a 1.4 service factor based on motor nameplate horsepower.
- f. The speed reducer shall be as manufactured by SEW Eurodrive, Inc., Nord Gear Corp., or equal.

#### D. Conveyor Supports

1. The conveyor troughs shall be supported using saddle type supports shaped to the profile of the troughs and extending to a common fixed distance below the centerline of the screw. Saddle type supports shall be located not greater than 10-foot center-to-center. Separate support points shall be provided under the drive end and tail end assemblies. These supports are to be welded as an integral part of these assemblies.
2. Stiffeners shall be placed across the top of the trough and fastened on both sides. Stiffeners shall be designed to maintain the trough shape under loading and shall also act as a face seal for the covers. Stiffeners shall be located so as not to impede the removal of maximum screw lengths as listed herein.

3. Support loadings are to be based on a completely filled trough, weight of the conveyor and the dynamic loading when operating.
4. The Contractor shall coordinate with the Conveyor Equipment Supplier support locations with the facility structural constraints. Access to other process systems and equipment shall not be restricted by the conveyor supports.
5. Each conveyor shall be field shimmed as required to conform to the manufacturer's installation tolerances.
6. Supports shall be constructed of ASTM A-36 structural steel shapes. Support members shall be hot dip galvanized coated to a minimum 3-4 mils DFT per ASTM A123.

#### E. Shaftless Screw Assemblies

1. The shaftless screw flights shall be cold rolled spirals fabricated from high strength carbon spring steel bars with a minimum tensile strength of 87,000 psi and a minimum Brinnel hardness of 220. Screw assemblies shall be provided with a dual spiral. Outer spiral flights shall have a minimum thickness of 1-inch and a minimum width of 2-3/4 inches. Inner spiral flights shall have a minimum thickness of 5/8-inch and a minimum width of 1-1/2 inches.
2. The manufacturer shall demonstrate that the drive unit cannot produce enough torque, at 250 percent of the motor nameplate horsepower, to exceed the torsional rating of the shaftless spiral. The spiral deflection shall not exceed 0.010 inches per foot of length at the maximum loading condition.
3. Shaftless screw conveyor spiral flights shall be formed in a forming machine to the diameter and pitch required. Spirals shall be concentric to  $\pm 0.080$ -inch maximum. Each formed section shall be factory welded into full lengths. Where the length of the conveyor precludes shipping, sub-sections of flighting shall be divided into maximum shipping lengths and welded together in the field.
4. Field splicing of flighting sections shall be by full penetration welds done in strict accordance with the manufacturer's instructions using AWS certified welders.
5. The spiral flighting outside face shall be flat and smooth with round edges. The outside face shall be parallel with the flight centerline axis.
6. Spiral flighting shall be connected to the drive shaft using a flanged connection plate that shall be welded to the spiral on one end. Transition between the flighting and connection flange shall be smooth and fabricated to the tolerances listed below. The drive shaft shall have a matching mating flange and shall be bolted to the flight connection plate.

7. Flighting shall be formed accurately to the pitch required within  $\pm 5/32$ -inch, with an average deviation of the pitch not exceeding  $\pm 0.050$ -inch over the length of the conveyor. Flanged faces shall be machined to  $\pm 0.001$ -inch perpendicular to the centerline axis of the screw. Screw pitch shall be measured at the outside diameter of the screw flights along four (4) straight lines parallel to the axial centerline of the spiral at  $90^\circ$  offsets and shall not vary more than  $\pm 0.02$  times the screw flight outside diameter from the design pitch.
8. The manufacturer is to repair, or replace, the spiral flighting not found in compliance with the aforesaid tolerances with new equipment until the spiral flighting meets the dimensional tolerance requirements. All refurbishment and payments necessary for ascertaining the dimensional tolerance of repaired or new replacement equipment shall be borne by the equipment manufacturer.
9. Shaftless flighting shall receive a shop coat of primer.

#### F. Shafted Screw Assemblies

##### 1. Shafts

- a. Screw conveyor shafts shall be fabricated from Schedule 40 (minimum thickness) Type 304 stainless steel pipe with a minimum shaft outside diameter as specified elsewhere in this specification. The shaft thickness shall be suitable for the expected static and dynamic loadings for each conveyor type specified herein.
- b. The allowable shaft deflection between two bearing support points shall not exceed  $3/32$ -inch for a simply supported tube with a uniform loading equal to the mass of the tube and associated flighting or the maximum center-to-center bearing distance as specified elsewhere herein.
- c. Each shaft section shall be constructed from a single piece of steel pipe (not fabricated by butt welding sections of pipe). Each shaft end shall be fitted with an appropriate coupling arrangement for affixing the shaft to adjoining shafts, the drive end assembly or the tail end shaft assembly. Couplings shall be Type 304 stainless steel and use stainless steel fasteners.
- d. The coupling bolt holes shall be designed to allow for removal of the bolts with the shaft center tube installed in the conveyor without removal of adjoining conveyor sections.

##### 2. Flights

- a. Flights shall be fabricated from Type 304 stainless steel with a minimum thickness of  $1/4$ -inch.

- b. Flights shall be of sectional construction, pre-cut, with uniform thickness and formed accurately to the design pitch. Radial welds of the sectional flight segments shall be level-welded, full and continuous on both sides of the flight junctions to the shaft.
- c. Flights shall extend beyond the end of the screw conveyor shaft to within 3/16-inch of the trough end plates and intermediate bearing supports to clear material from inlet and outlet chutes and drain connections.
- d. Following fabrication of the screw assembly (flights mounted to shaft) the assembly shall be mounted in a finishing jig and the flight outside diameter trimmed to a true circular diameter about the centerline axis of the shaft tube within  $\pm 0.050$ -inches.
- e. Flighting shall be formed accurately to the pitch required within  $\pm 5/32$ -inch, with an average deviation of the pitch not exceeding  $\pm 1/8$ -inch over the length of the conveyor between bearings. Flanged faces shall be machined to  $\pm 0.001$ -inch perpendicular to the centerline axis of the screw. Screw pitch shall be measured at the outside diameter of the screw flights along four (4) straight lines parallel to the axial centerline of the spiral at 90° offsets and shall not vary more than  $\pm 0.02$  times the screw flight outside diameter from the design pitch.
- f. The manufacturer is to repair, or replace, the spiral flighting not found in compliance with the aforesaid tolerances with new equipment until the spiral flighting meets the dimensional tolerance requirements. All refurbishment and payments necessary for ascertaining the dimensional tolerance of repaired or new replacement equipment shall be borne by the equipment manufacturer.

### 3. Intermediate Bearings

- a. The conveyor flighting shall be supported by CEMA Style 226 type 304 stainless steel hanger bearing brackets with hardened iron bearings, hardened coupling shafts and grease pipe extensions. Intermediate bearings shall be provided on shafted conveyors with a maximum center-to-center separation between bearings not greater than 12'-0". The intermediate bearing assembly shall be designed to allow removal of the bearing assembly without removal of the adjoining rotors, shafts, or bearings.
- b. The conveyor flights shall cantilever beyond the rotor end on each side of the bearing such that the gap or missing space without blade shall not be greater than 3-inches. The extended flight sections shall be supported from the adjacent torque tubes to accommodate the intermediate bearing support bracket. The bearing shall conform to the standards of the AFBMA and shall have a minimum L-10 life of 50,000 hours.

- c. Intermediate bearing assemblies shall accommodate torsional load, misalignment, and longitudinal movement in two directions due to thermal expansion and differential loadings of the screw conveyor rotors both upstream and downstream due to sludge loading. Intermediate bearings shall be free-floating transmitting thrust loadings to one end of the conveyor where the thrust end fixed bearing is fitted.
- d. Seals shall be provided on both sides of the intermediate bearing to prevent sludge contamination of bearings and grease leakage into the conveyed sludge.
- e. The intermediate bearing shall be supported by both sides of the conveyor trough using support brackets with bolted connection through the trough walls.
- f. Type 304 stainless steel tubing shall be provided to transmit grease from the grease fitting mounted external to the conveyor trough to the intermediate bearing. The bearing housing shall be equipped with an access port allowing grease to enter the central bearing area and seal assembly. Grease tubing shall be routed to prevent damage to the tubing from the material being conveyed and to prevent clogging or bridging of the conveyed material.
- g. The intermediate bearing shall be equipped with a spring-loaded lubricator assembly. The lubricator assembly shall be located above each intermediate bearing location. The lubricator assembly reservoir shall be equipped with a metal base complete with base coupling, piston with O-rings, compression springs, and filling connections.

## G. Safety Devices And Limit Switches

### 1. Safety Trip Cords

- a. Each screw conveyor shall be furnished with emergency trip cords running on both sides of the conveyor and a safety stop switch in compliance with OSHA standards.
- b. Trip cabling shall be 3/16-inch O.D. fabricated of internal 3/32-inch 7 x 7 strand galvanized aircraft cable and orange colored nylon outer sheathing. Cabling shall be supported by galvanized steel or chrome plated eyebolts every 10 feet. Wire clamps shall be stainless steel.
- c. The switch assembly shall be able to handle up to 20 feet of conveyor length. Safety switch shall be housed in a NEMA 7 explosion-proof enclosure and shall have a DPDT micro-switch and stainless steel external hardware. Emergency trip cord and safety switch shall be Conveyor Components Company Model RS-2X, or equal.

## 2. Zero Speed Switches

- a. Provide non-contacting, proximity-type speed switch on screw conveyors to detect zero speed condition. The zero-speed switch shall consist of a sensor/pre-amplifier and an amplifier/output unit. For shafted screw conveyors, the switch shall be located on the non-driven end of shafted conveyors.
- b. The sensor/pre-amplifier shall utilize magnetic proximity effect to detect equipment rotational speed without physical connection to the rotating equipment. Sensors shall provide output pulses in proportion to rotational speed by detection of a ferrous target mounted on the rotating equipment for shaftless screw assembly and by detection of the rotating flights of a shafted screw assembly. The sensor shall operate satisfactorily with air gaps of up to 4". The sensor/pre-amplifier shall be provided complete with mounting flange, threaded body and locknut.
- c. The amplifier/output switch unit shall provide two SPDT contacts that operate on detection of an under-speed operating condition. The SPDT contact outputs shall be rated for 5A at 120 volts AC. The unit shall include an adjustable start-up delay of 0 to 60 seconds to override zero speed alarm during initial acceleration. Units shall operate on 120-volt AC power. Provide set point adjustment range of 2 to 3,000 pulses per minute.
- d. Zero speed detection switches shall be Milltronics MFA-4 with MSP-12 sensor/pre-amplifier, suitable for installation in a Class 1, Division 2 environment, or equal.

## 3. Pressure Relief Cover Limit Switches

- a. Each pressure relief cover shall be furnished with a limit switch for detection of a pressure relief operating condition and initiation of conveyor shutdown. Limit switches shall be of a heavy-duty design suitable for installation in a Class 1, Division 2 environment, as furnished by Square D, or equal.

### **2.04 ELECTRICAL REQUIREMENTS**

- A. All motors and all necessary items integral to the mechanical screen required for proper screen operation and control shall be furnished and installed, as described herein and shall be ready for the electrical connections to be made under Division 26 of the Specifications. The Contractor shall coordinate screen controls with the requirements of Division 40.

B. Motor Schedule:

	Screen Drive	Conveyor
Rating	460V, 3 ph, 60 Hz	460V, 3 ph, 60 Hz
Maximum Horsepower	3	3
Speed, rpm	1800	1800
Enclosure	TEFC-XP	TEFC-XP
Insulation	Class H	Class H
Inverter Duty	Yes	No
Service Factor	1.0	1.0
Motor Winding Temperature Switches	No	No

- C. Motors shall be provided with a separate heavy gauge aluminum conduit box for power connections. A grounding lug shall be provided inside the conduit box. Motors shall be as specified in Section 26 05 60 – Low-Voltage Electric Motors.
- D. All electrical appurtenances furnished by the equipment manufacturer shall be rated for installation in a Class I, Division 2, Group D, hazardous location.
- E. All conduit, couplings, fittings, and fasteners furnished by the equipment manufacturer shall be PVC coated rigid aluminum and liquid tight, PVC coated, flexible metal conduit to suit the application. Conduit seals shall be furnished and installed as required.
- F. All electrical components mounted on the mechanical screen shall be wired to NEMA 7 cast aluminum screen mounted junction boxes, one power and one control, complete with terminal strips. Wiring shall be completed to the control panel by the Contractor.

**2.05 CONTROL EQUIPMENT**

A. Control Panel

1. The screening equipment manufacturer/supplier shall provide a local control panel for the screen drive and screenings conveyor. All control equipment for both an individual screen drive and respective screenings conveyor shall be housed in a single common panel. Provide a U.L. listed or recognized control panel in an indoor, NEMA 1A enclosure. IEC rated devices are not acceptable. All controls and other ancillary local control panel equipment not listed herein shall also be provided. Components of the Control Panel shall meet the applicable requirements of Division 26.
2. The Control Panel shall be furnished, completely pre-wired and factory tested, requiring only mounting and connection to external wiring in the field by an electrical contractor.



3. The screen manufacturer shall be responsible for proper sizing of the panel to meet dimensional constraints, as shown on the Drawings. The control panel shall include, but not be limited to, the following:

a. General Requirements

- 1) A single 480 VAC three-phase power supply connection with a circuit breaker-type, lockable disconnect switch operable from outside the control panel.
- 2) Internal step-down transformers as required to achieve 120VAC control voltage
- 3) A Programmable Logic Controller (PLC) shall be provided in accordance with specification 40 63 43 and used to control the motor controllers as described in the Control Operations section below.
- 4) Provide cabinet ventilation as necessary for an indoor, dry non-air-conditioned control panel location.

b. Multi-Rake Bar Screen Requirements

- 1) An AC variable frequency drive (VFD) suitable for forward-reverse and fast-slow operation of the screen drive motor. Provide the VFD with a branch circuit breaker, an input reactor and solid-state overload relay.
- 2) Hand-Off-Auto (H-O-A) control switch with AUTO control provided by the control panel provided under this Section.
- 3) E-STOP pushbutton
- 4) FORWARD-REVERSE selector switch
- 5) An elapsed RUN TIME meter
- 6) The following door-mounted 30.5mm push-to-test indicating lights shall be provided to indicate running and alarm status of the screen. Legend plates and a door-mounted Alarm RESET push button shall also be provided.
  - a) POWER ON indication light
  - b) LOCAL/REMOTE indication light
  - c) RUN-FAST indication light
  - d) RUN-SLOW indication light

- e) FAIL indication light
  - f) OVERCURRENT indication light
  - g) E-STOP indication light
- c. Screenings Conveyor Requirements
- 1) NEMA rated, reversing, combination motor starter complete with motor circuit protector and solid-state overload relay.
  - 2) Hand-Off-Auto (H-O-A) control switch on the front of the control panel with AUTO control provided by the panel provided under this Section.
  - 3) E-STOP pushbutton
  - 4) FORWARD-REVERSE selector switch
  - 5) An elapsed RUN TIME meter conveyor
  - 6) The following door-mounted 30.5mm push-to-test indicating lights shall be provided to indicate running and alarm status of the screenings conveyor. Legend plates and a door-mounted alarm RESET push button shall also be provided.
    - a) POWER ON indication light
    - b) LOCAL/REMOTE indication light
    - c) RUN indication light
    - d) FAIL indication light
    - e) OVERCURRENT indication light
    - f) E-STOP indication light
4. The PLC shall provide the following I/O points for output to the plant control system for remote indication and alarm:
- a. Screen RUN FAST indication
  - b. Screen RUN SLOW indication
  - c. Screen FAIL indication
  - d. Screen OVERCURRENT indication

- e. Screen E-STOP indication
- f. Screenings Conveyor RUN indication
- g. Screenings Conveyor FAIL indication
- h. Screenings Conveyor OVERCURRENT indication
- i. Screenings Conveyor E-STOP indication
- j. Level Differential (analog output)

B. Manufacturer supplied PLC Requirements

1. The manufacturer-supplied PLC shall be furnished, installed and programmed by the manufacturer. The PLC shall continuously monitor and control the associated system and provide all the required alarms, indications of system parameters, equipment status, etc. to the main control system at the plant.
2. Where individual equipment PLCs are not required to be connected to the plant control system via the data highway network, they shall provide the individual hardwired signals as specified in the Contract Documents. Outputs to the plant control system are described in the Drawings, the Input/Output Schedule, the individual equipment specification sections, and in Section 40 61 96 – Functional Control Descriptions.
3. The operator interface for control of each individual system shall be performed by local operator interface units as specified in Section 40 62 63 or individual pilot devices on the equipment local control panel as specified in the associated equipment specification section.
4. Where remote indication is required to be provided to the plant control system, the individual system supplier shall be responsible for coordination with the instrumentation subcontractor to provide a complete and working equipment control system. The equipment supplier shall coordinate testing of the completed system with the instrumentation subcontractor, which shall conform to the requirements of Section 40 61 21.72 – Field Testing.
5. The Contractor, equipment supplier and instrumentation subcontractor shall coordinate testing and startup of the equipment provided by the equipment supplier with the plant control system, including but not limited to the following tasks:
  - a. Provide assistance with control system testing of inputs, outputs, and control strategies as needed.

- b. Provide support or interface work necessary to perform physical checkout and field testing to the final field devices. The schedule may require the instrumentation subcontractor and equipment manufacturer personnel to perform loop checks simultaneously, as directed by the Design-Builder
  - c. Coordinate and assist as needed to maintain I/O connectivity throughout the system.
  - d. Ensure personnel safety while equipment is exercised via the plant control system.
  - e. Ensure that process, instrumentation, and control equipment are not damaged while equipment is exercised via the plant control system.
  - f. Provide temporary modifications to field devices and their terminations, if needed.
  - g. Providing labor and supervision, which may include, but is not limited to, the following: electricians, instrument technicians, manufacturer's representatives, and individual(s) knowledgeable about process startup and operation.
  - h. Operation of process equipment for verification of each plant control system input and output.
- C. Ultrasonic Level Sensors and Differential Level Transmitter shall be provided by the screen manufacturer in accordance with specification 40 72 13. Provide 120 VAC power for the differential level transmitter from the Control Panel from an isolated circuit protected by a circuit breaker. Circuit breaker shall be pre-wired to terminal blocks for Contractor use.

## **2.06 CONTROL OPERATIONS**

- A. LOCAL/OFF/REMOTE handswitches shall be provided by the Contractor for both the screen and the screenings compactor located near the equipment as shown on the Drawings. In the OFF position, the associated equipment shall not run. In the REMOTE position, the associated equipment shall be controlled by the factory control panel. In the LOCAL position, the associated equipment shall run in the direction (conveyor) or speed (screen) selected at the factory control panel.
- B. An EMERGENCY STOP handswitch shall be provided by the Contractor for the screen located near the screen as shown on the Drawings. When the EMERGENCY STOP handswitch is depressed, the screen shall stop immediately and not run until the handswitch is reset. An EMERGENCY STOP pull cord shall be provided for the conveyor by the conveyor manufacturer. When the EMERGENCY STOP pull cord is engaged, the conveyor shall stop immediately and not run until the pull cord is reset.

- C. When the screen is in the REMOTE HAND mode, the screen shall be started and stopped at the vendor control panel FCP-SCR-1 and shall operate in accordance with Forward/Reverse selector switch. In the REMOTE OFF mode, the screen shall not run under any condition. In the REMOTE AUTO mode, the bar screen shall be controlled by the vendor control panel control logic as described below.
1. Under normal conditions, the screen shall operate in the REMOTE AUTO mode controlled by an adjustable on/off PLC cycle timer on a timed basis. ON and OFF cycle times shall be operator adjustable between 0 and 60 minutes.
  2. If the level differential is below an operator-adjustable setpoint, the screen shall run in the SLOW mode according to the selected ON and OFF cycle times.
  3. If the differential level increases to the operator selected set point, the screen shall run continuously in the FAST mode until the differential level has dropped below the operator-selected setpoint.. The screen shall then resume normal AUTO operation running in SLOW mode according to the selected ON and OFF cycle times.
  4. If the differential level increases to a second, higher operator-selectable set point, the screen shall continue to operate in FAST mode and a HIGH DIFFERENTIAL LEVEL ALARM output shall be generated for remote alarm.
- D. When the screenings conveyor is in the REMOTE HAND mode, the screenings conveyor shall be started and stopped at the vendor control panel and will operate in accordance with the Forward/Reverse selector switch. When the conveyor is in the REMOTE OFF mode, the screenings conveyor shall not run under any condition. When the conveyor is in the REMOTE AUTO mode, the screenings conveyor shall be controlled by the vendor control panel as described below.
1. The screenings conveyor shall start whenever the mechanical screen starts.
  2. The screenings conveyor shall stop after an operator-adjustable time delay (initially set at 30 seconds) after the mechanical screen has stopped.
  3. If the screenings conveyor fails to start within a time delay (initially set at 5 seconds) after the screen is started, a CONVEYOR FAIL signal shall be generated for remote alarm. The screen shall continue to run.

## **2.07 ACCESSORIES, SPARE PARTS, AND SPECIAL TOOLS**

- A. Spare parts and accessories shall be provided by the Contractor as specified in Section 46 00 00 – Equipment General Provisions.
- B. The spare parts which are identical and interchangeable with the original parts shall be furnished in clearly identifiable and labeled containers.

- C. The Contractor shall furnish all special tools (one per like piece of equipment) necessary to disassemble, service, repair and adjust the equipment.
- D. The Contractor shall furnish spare parts as recommended by the equipment manufacturers in addition to those listed below.
- E. Spare parts shall be packaged with labels bearing the description and quantity of the contents.
- F. The following spare parts shall be provided for each mechanically cleaned bar screen:
  - 1. Two (2) sets (10 linear feet each) of chain
  - 2. One (1) set (2 pieces) of lower sprockets (including polyethylene bushes)
  - 3. One (1) set (2 pieces) of upper sprockets
  - 4. One (1) set (2 pieces) of stub shaft assembly (consists of stub shaft, bonded ceramic collar, polyethylene washers (2 pieces), retaining rings, and spring pin or as pertinent to manufacturer design)
  - 5. Two (2) rake bars
  - 6. Two (2) shear bolts

**PART 3 – EXECUTION**

**3.01 MANUFACTURER’S FIELD SERVICES**

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions, and shall include the following site visits:

<b>Service</b>	<b>Number of Trips</b>	<b>Number of Days/Trip</b>
Installation and Testing	1	2
Startup and Training	1	3
Services after Startup	1	1

**3.02 FIELD TESTING**

- A. Testing shall be in accordance with Section 46 00 00 – Equipment General Provisions.
- B. The bar screen shall be field tested after installation, and in the presence of the Engineer and manufacturer’s representative, to confirm and verify the structural and mechanical compliance to the requirements specified. The field acceptance test shall include demonstrating that the screen can operate continuously without vibration, jamming or overheating and perform its specified function satisfactorily.

- C. All labor, materials, and test apparatus necessary for conducting the field acceptance tests shall be furnished by the Contractor at no additional cost to the Owner.
- D. Each screen shall be factory assembled and tested for a minimum of 1 hour prior to delivery to check alignment and clearances of the cleaning rakes, dead plate, and side frame guides. Each screen shall also be delivered to the site fully assembled (other than the motor/reducer unit, drive chain, chain cover, discharge chute and support legs). It shall be capable of being set in place and field erected by the Contractor with minimal field assembly.
- E. Upon completion of the installation, each piece of equipment shall be tested for satisfactory operation without excessive noise, vibration and overheating. All equipment must be adjusted and checked for misalignment, clearances, supports and adherence to safety standards.
- F. Any repairs recommended and normal replacement of components due to wear including additional spacers to limit tolerances related to materials and workmanship of the screens or to make adjustments to the screen shall be provided by the Contractor under the conditions of the warranty.

### **3.03 INSTALLATION**

- A. The screen shall be shipped assembled ready for installation into the channel. Where the screen cannot be shipped assembled due to carrier limitations, the screen frame shall be provided with bolted splice joints to facilitate assembly and/or disassembly of the bar screen during installation.
- B. If a screen is not shipped assembled this will not eliminate the requirement for complete shop assembly and testing of the bar screen before shipment.
- C. All equipment specified herein shall be installed and tested by the Contractor in accordance with the manufacturer's instructions and checked by the manufacturer's representative, in conformity with the applicable sections of this Specification. After installation, the equipment shall be aligned, balanced, and adjusted as required for proper operation and proper alignment.
- D. Where warning is necessary, safety hazard labels shall be attached to the equipment.

### **3.04 WELDING**

- A. The Equipment Manufacturer's shop welding procedures, welders and welding operators shall be qualified and certified in accordance with the requirement of AWS D1.1 "Welding in Building Construction" of the American Welding Society.
- B. The Equipment Manufacturer's shop drawings shall clearly show complete information regarding location, type, size and length of all field welds in accordance with "Standard

Welding Symbols” AWS A2.0 of the American Welding Society. Special conditions shall be fully explained by notes and details.

- C. The Contractor’s welding procedures, welders and welding operators shall be qualified and certified in accordance with the requirements of AWS D1.1 “Welding in Building Construction” of the American Welding Society.
- D. The Contractor shall perform all field welding in conformance with the information shown on the Equipment Manufacturer’s drawings regarding location, type size and length of all welds in accordance with “Standard Welding Symbols” AWS A2.0 of the American Welding Society, and special conditions as shown by notes and details.

### **3.05 PAINTING**

- A. All surface preparation, shop painting, field repairs, field painting and other pertinent detailed painting specifications shall conform to applicable sections of Section 09 90 00 – Painting.
- B. All inaccessible surfaces of the equipment which normally require painting, shall be shop finish painted by the manufacturer. The motor and gear reducer shall be painted in accordance with Section 09 90 00 – Painting.
- C. Gears, bearing surfaces, and other unpainted surfaces shall be protected prior to shipment by a heavy covering of rust-preventive compound sprayed or hand-applied which shall be maintained until the equipment is placed in operation. This coating shall be easily removable by a solvent.

### **3.06 EQUIPMENT IDENTIFICATION**

- A. The mechanical bar screen shall be provided with a substantial stainless-steel nameplate, securely fastened in a conspicuous place and clearly inscribed with the manufacturer’s name, year of manufacture, serial number, and principal rating data.

**END OF SECTION**